Using Buddhist Insights to Analyse the Cause of System Project Failures

Pita Jarupunphol

A thesis submitted in fulfilment of the requirements for
the degree of Doctor of Philosophy in Computer Science,
The University of Auckland, 2013

Declaration

These doctoral studies were conducted under the supervision of Professor Clark Thomborson and Associate Professor Timothy Teo.

The work presented in this thesis is the result of original research carried out by myself, in collaboration with others, whilst enrolled in the Department of Computer Science as a candidate for the degree of Doctor of Philosophy. This work has not been submitted for any other degree or award in any other university or educational establishment.

Pita Jarupunphol
30 August 2013

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Namo tassa bhagavato arahato samma sambuddhassa

Honour to the Blessed One, the Exalted One, the fully Enlightened One . . .

The Lord Buddha states that we are all interconnected. There are no accidents in life. Everything happens for a reason. People come into your life for a reason. I would like to acknowledge and express my gratitude to those below, who have become part of my interconnectedness and contributed to my thesis completion.

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Abstract

This thesis hypothesises that Buddhist insights can be useful in systems engineering and related disciplines. The thesis commences by arguing that *upadana*, or a condition of attachment can be considered as the root cause of problems in systems engineering. Definitions of attachment from psychology are also discussed in connection to the condition of attachment in Buddhism. Similarities and differences are pointed out.

A number of theories, approaches, and frameworks in systems engineering are reviewed and discussed in connection to the condition of attachment. A case study of Secure Electronic Transaction (SET) failures is used to illustrate that the condition of attachment underlies system project failures. This thesis provides the background behind the emergence of SET, a technical overview of it, issues of SET, attempted solutions, and emerging e-payment systems after SET failures.

Central to the thesis is the Dhammic framework, a novel theoretical framework grounded in the central tenet of Buddhism that represents states of mind from a Buddhist perspective. This thesis formalises states of mind from Buddhist Dhamma using a formal method in order to avoid ambiguity. The framework is based on chosen doctrines from Buddhist Dhamma and a formal method to logically represent how the reality of a phenomenon is rooted in an individual's perceptions. Psychological constructs underlying how a condition of attachment is derived, where a condition of attachment is situated, and why a condition of attachment can be undesirable are pointed out. The Dhammic framework can be considered as an iconoclastic framework that is not utilised in existing analytical frameworks for understanding system project failures in the literature, but worth considering in systems engineering.

Dhammic TAM (DTAM), which is based on TAM (Technology Acceptance Model) extended by the condition of attachment in Buddhism, is tested using empirical data in order to investigate if the condition of attachment should be considered as a critical construct for predicting behavioural intentions toward using a system. The methodology and the experimental results with reference to DTAM are also discussed in the thesis. The results also confirm whether or not the condition of attachment in Buddhism can be useful in systems engineering and related disciplines.

The thesis also discusses *Majjhima Patipada* or the Middle Path (MP), which is an insight for dealing with conflicts in Buddhism. Different MP theories are discussed in reference to modern conflict resolution theories in psychology. Given that the condition of attachment plays an important role in system acceptance, the thesis recommends Buddhist MP systems engineering as an appropriate path for avoding system project failures.

Abbreviations

3D SET	Three Domain SET
3-D Secure	3-Domain Secure
ACS	Access Control Server
AM	Attachment Towards Using
ATU	Attitude Towards Using
BSM	Buddhist Systems Methodology
CA	Certification Authority
CM	Confirmation Message
CMQF	Conceptual Model Quality Framework
CP	Certificate Policy
CPs	Cognitive Processes
CR	Checkout Request
CRE	Confidentiality Requirements Elicitation and Engineering
CRL	Certificate Revocation List
DES	Data Encryption Standard
DMAIC	Define Measure Analyse Improve Control
DTAM	Dhammic TAM
E-Commerce	Electronic Commerce
EMV	Europay MasterCard Visa
FR	Functional Requirements
GQM	Goal, Question, Metric
GST	General Systems Theory
IC	Integrated Circuit
ID	Identifier

IDEA	International Data Encryption Algorithm
IEC	International Electrotechnical Commission
INCOSE	International Council on Systems Engineering
ISO	International Organization for Standardization
ITU	Intention to Use
LRMB	Layered Reference Model of the Brain
MP	Middle Path
MPI	Merchant Plug-In
NFR	Non-Functional Requirement
NL	Natural Language
NLSS	Natural Language Syntax and Semantics
OI	Order Information
PA	Payment Authorisation
PAR	Payment Authorisation Request
PEOU	Perceived Ease of Use
PI	Payment Information
PIN	Personal Identification Number
PK	Public Key
PKC	Public Key Cryptography
PKI	Public Key Infrastructure
POS	Point of Sale
PU	Perceived Usefulness
QFD	Quality Functional Deployment
QMF	Quality Management Framework
RE	Requirements Engineering
RSA	Rivest Shamir Adleman
SA	Secret Authentication
SAR	Secret Authentication Request
SEM	Structural Equation Modeling
SEI	Software Engineering Institute

SET	Secure Electronic Transaction
SHSM	Six Honest Serving Men
SPA	Secure Payment Application
SPR	Software Productivity Research
SQUARE	Security Quality Requirements Engineering
SQuaRE	Software Product Quality Requirements and Evaluation
SR	SET Request
SRCM	System and Requirements Classification Model
SSM	Soft Systems Methodology
SSL	Secure Sockets Layer
SW	SET Wake-up Message
TAM	Technology Acceptance Model
TCG	Trusted Computing Group
TCPA	Trusted Computing Platform Alliance
TLS	Transport Layer Security
TPB	Theory of Planned Behaviour
TQM	Total Quality Management
TRA	Theory of Reasoned Action
TTP	Trusted Third Party
URL	Uniform Resource Locator
UTAUT	Unified Theory of Acceptance and Use of Technology
VDir	Visa Directory
WOSP	Web of System Performance
XP	Extreme Programming

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Part 1

Upadana in Systems Engineering

CHAPTER 1

Introduction

> "Buddhism, like science, presents itself as a body of systematic knowledge about the natural world, and it posits a wide array of testable hypotheses and theories concerning the nature of the mind and its relation to the physical environment... A major difference between science and Buddhism is that scientists largely exclude subjective experience from the natural world and attribute causal efficacy only to physical phenomena. Buddhism, in contrast, takes subjective mental phenomena at least as seriously as objective physical phenomena and posits a wide range of interdependent causal connections between them", Wallace [**349**].

1.1. Introduction

Buddhist insights can be worthy of consideration in systems engineering and related disciplines. According to Shen and Midgley [**309**], Buddhism has been applied to different systems engineering theories and methodologies (e.g. Soft Systems Methodology (SSM), Systems Thinking, General Systems Theory (GST). Shen and Midgley proposed Buddhist Systems Methodology (BSM) based on various Buddhist doctrines, and applied BSM to non-Buddhist organisations. A number of positive results were discovered by the 6-month experiment, including communication improvement, conflict reduction, and staff retention. Shen and Midgley further suggest that restructuring based on BSM can help address several underlying issues related to communication barriers across organisations. They claim that BSM can be used effectively in Taiwan and is potentially applicable to other Buddhist organisations.

In terms of system quality improvements, Bevan [**72, 73, 74**] argues that quality in use should be the major design objective, rather than technical and process specifications, since it is directly concerned with many aspects of user satisfaction. Bevan proposes a framework for assessing quality in use via Buddhist concepts such as ignorance, uncertainty, awakening, enlightenment, wisdom, and certainty. In this thesis, the condition of attachment in Buddhism, known as 'Upadana', will be considered as a possible cause of success and failure in systems engineering. Understanding attachment will provide systems engineers with insights into developing systems, which could help them avoid system project failures caused by attachment conflicts. This chapter begins with a discussion of attachment in Buddhism in comparison to attachment in psychology. This chapter also discusses how complexity is

viewed in systems engineering and Buddhism. The thesis structure is outlined at the end of the chapter.

1.2. Upadana – The Condition of Attachment

According to the Oxford Dictionary of Buddhism [**222**], 'Upadana' is defined as 'clinging or grasping driven by an intensified form of attitude'. It is a condition in which our mind is bound or attached to a perceived phenomenon. This state of mind in Buddhism is also known as 'attachment' [**37, 129, 166, 198**]. It is similar to the concept of attachment in psychology, which is related to an emotional bond to another person [**47, 85, 86, 91**]. According to Bowlby [**85, 86**], attachment is a relationship-based construct; it is the emotional bond joining a person to another human being. In Ainsworth [**47**, p.17], attachment was defined as a more specific relationship; 'a bond, tie, or enduring relationship between a young child and his mother'. Most attachment terms identified in psychology are strongly bound to intensely positive emotions. A number of attachment experiments in psychology are widely used to investigate bonds between human beings. Different ages and genders have been extensively studied in psychological experiments. For example, Thomson et al. define emotional attachment by using three major categories, connection, passion, and affection, to measure emotional attachment. These emotional attachment categories are based on adult romantic attachment, as described by Hazan and Shaver [**181, 182, 183**], consisting of different terms of intensified positive attitudes; affectionate, friendly, loved, peaceful, passionate, delighted, bonded, and attached.

While the initial work on attachment in psychology focused on interpersonal relationships, Thomson et al. [**341**] also defined attachment as an emotion that connects an individual and a specific object in marketing. Attachment is considered an important factor in influencing consumer purchases. For example, brand attachment is studied in marketing to understand how a consumer strongly connects to a certain brand. It varies in strength from weak to strong, and is considered a more powerful driver of behavior than attitude because of its emotional implications [**278**]. Favourable or unfavourable attitudes do not develop from an individual's direct interaction with an object; conversely, attachment develops over time and often depends on the history of interactions between a consumer and his/her attachment object. Attitude is changeable, but there is temporal stability in attachment. A favourable attitude towards a product may not persist long enough for a consumer to actually purchase it. However, an attachment to a product is a long-term phenomenon, known as 'brand loyalty' or 'brand acceptance' in marketing literature [**246, 278, 341**].

1.3. Attachment in Buddhism

Although attachment in psychology consists of a combination of emotion and attachment, attachment in Buddhism is just 'the condition of attachment itself', which is separated from emotions. Attachment in Buddhism is neither attitude nor intention towards a system, but

is situated between an intensified degree of attitude (*tanha* or 'craving' in Buddhism) and an intention (*cetana*). In this case, attachment in systems engineering from a Buddhist perspective can be simply defined as "the degree of a bond of a user to a system".

Several kinds of emotional attachment in psychology are strongly related to an intensified degree of attitude in Buddhism, which is a pre-condition of attachment (see the section on Dhammic framework in Chapter 4). This attachment is driven by intensified positive or negative attitude. For example, a user who attaches to intensified positive attitudes will use a system for a certain period of time, until the degree of attachment to the positive attitudes declines. However, a user who attaches to intensified negative attitudes will reject the system for a certain period of time, until the degree of attachment to the negative attitudes declines.

This condition of attachment is central to the user's behaviour, as it underlies how individuals perceive and respond to phenomena. It is a state of mind that underlies any human justification or reaction to a system. In other words, our intention towards any phenomenon is always influenced by the condition of attachment. In many cases, the user ignores the attachment or is unaware of it, even when his/her behaviour is thereby influenced.

While attachment in psychology is strongly related to an emotion that connects an individual and a specific person or object, there are no specific boundaries to attachment in Buddhism. Instead, Buddhism emphasises that the condition of attachment occurs in human perceptions when a phenomenon is perceived. Attachment is always associated with the perception and judgment of a phenomenon. Since our mind is bound to the phenomenon, our attachment is always associated with either deductive or inductive reasoning. Any perceivable phenomenon can fall into the condition of attachment; for example, a system engineer might attach to his own views about how a system should be engineered, or a user might attach to such a system. As such, attachment in Buddhism consists of four dynamically dependent conditions [**222**]: 1) kamupadana (clinging to pleasurable sensual experiences and/or sensuality); 2) ditthupadana (clinging to views and/or theories); 3) silabbatupadana (clinging to rules and/or rituals); and 4) attavadupadana (clinging to belief in self and/or wordings).

1.3.1. Sensuality Attachment. Sensuality attachment, or clinging to pleasurable sensual experiences, is the extent to which a person is emotionally connected to the sensuality perceived in a system. In other words, a person attaches to a system due to this perceived sensuality; for example, because of the ease of use of the system.

This kind of attachment can be further used to describe similar situations in psychology and marketing. In psychology, a child attaches to an attachment figure because of the security or comfort they perceive coming from the attachment figure. In marketing, a customer attaches to a brand due to the security they perceive in the brand.

Security here refers to trust, which is defined as either the willingness to accept the outcomes of one's own behaviour, or the ability to rely on another person to accept consequences on one's behalf [**348**]. In this context, security is a feeling.

Secure attachment in psychology can be used to describe sensuality attachment in Buddhism. Confidence plays a major role in the development of emotional attachment to a system, in the same way as children are attached to their parents. The extent to which children are secure can be determined by assessing their confidence in parents. Parents provide protection, reassurance and comfort to their children. Similarly, the degree to which a person is secure can be determined through an assessment of their confidence in a particular system. In a systems context, secure attachment means confidence in an innovation that individuals can rely on to perform its stated purpose. Conversely, insecure attachment can mean a lack of confidence in a system that individuals cannot rely upon to perform its stated purpose.

1.3.2. View Attachment. View attachment, or clinging to views and theories, is the extent to which a person attaches to his or her view. This condition of attachment can be explained by the notion of belief, which here refers to 'the attitude we have, roughly, whenever we take something to be the case or regard it as true' [**3**]. Belief is the psychological state in which an individual holds a proposition or premise to be true [**4**]. In the Oxford Dictionary of Philosophy [**76**, p.85], belief is defined as 'a mental state, representational in character, taking a proposition (either true or false) as its content and involved, together with motivational factors, in the direction and control of voluntary behaviour'.

In most cases, belief is ignored and its validity goes unquestioned, since it is associated with our perception of phenomena [**235**]. Put simply, view attachment in Buddhism is the extent to which a person attaches to his/her beliefs. Because a person attaches to the sensuality perceived from the system, they will automatically believe that the system possesses sensuality that the person is emotionally bound to. In other words, the person attaches to his/her belief that the system possesses a quality fulfilling his/her sensuality. For example, a person might attach to a belief that a system is easy to use. The person believes the system to be right or wrong because their view is connected to the attached sensuality.

The notion of view attachment in Buddhism can be illustrated by the notion of secure base in psychological attachment, in which children attach to the belief that an attachment figure acts as a base of security.

1.3.3. Ritual attachment. Ritual attachment, or clinging to rules and rituals, is the extent to which a person attaches to certain rituals or courses of action that will allow him/her to fulfill his/her belief. This ritual attachment is relevant to the notion of superstition [**298**]. According to the Penguin Dictionary of Psychology [**94**], superstition is defined thus:

> "any notion or belief held in the absence of what one not holding that notion or belief would consider to be adequate evidence to substantiate or support it sufficiently to maintain it."

Superstitious behaviour, on the other hand, 'results from and is maintained by adventitious reinforcements which are, in reality, not specifically coordinated with it'. In Buddhism, however, ritual attachment is considered as superstitions belief, because it is initially conditioned

by sensuality attachment. Any notion or belief in certain patterns of behaviour is considered superstitious, no matter how rational or irrational. The user who attaches to a belief about a system will automatically attach to certain behaviours towards belief.

For example, the user who feels secure attachment to the system will attach to certain behaviours that make him/her feel secure in using the system. Similarly, the user who feels insecure attachment to the system will attach to certain behaviours that, in rejecting the system, make him/her feel secure. The system engineer will attach to certain patterns in addressing the system so as to maintain his/her belief.

This notion of pattern attachment in Buddhism can be illustrated by the concept of safe haven in psychological attachment, in which children return to an attachment figure perceived as a secure base for comfort and safety. Whenever they feel insecure in any environment, they will return to this safe haven; in this way, they attach to the behaviours that they can use to feel secure.

1.3.4. Self Attachment. Self attachment, or clinging to belief in self and wordings, is the extent to which a person attaches to *atta* (self) and *vada* (wordings) in response to his/her attached sensuality, views on sensuality, precepts and procedures. A person is emotionally bound to his/her self and wordings as they repeatedly occur (e.g., my system, my theory, my framework, my procedures, etc.). Self attachment in Buddhism is similar to the idea of self-concept in psychology, which is directly tied to attachment. According to Read et al. [**288**], the concept of self-schema is intrinsically connected to attachment. Park et al. [**278**, p.4] state that, in marketing, 'attachments develop over time as relationships between the self and the entity evolve'.

The importance of self-concept is underlined by the fact that individuals use products or brands to demonstrate their self-concepts to themselves [**246**]. Individuals define, maintain and develop their self-concept through consumption of brands. The outcome of this is self-concept congruity, which defines a consumer's perceptions of the product, self and consumer-brand relationship. Notably, self-concept congruity is part of the attachment construct. Individuals form their perception of self-concept through processing their interactions with products, by creating tales or imposing a narrative structure on their experiences. A consumer who has a longer experience/interaction with a brand is more likely to have a foundation to develop brand-self perception.

In a systems context, a system is secure or insecure because a user or a systems engineer justifies the system as secure or insecure. The user accepts or rejects the system because 'he' or 'she' justifies that accepting or rejecting the system can make the system secure or insecure for him or her. Likewise, the systems engineer designs or optimises the system because 'he' or 'she' justifies the system's security or insecurity as a result of his/her design or optimisation approaches or techniques.

In Buddhism, self attachment is also associated with wordings to which individuals become accustomed without carefully evaluating their definitions. For example, the systems

engineer uses the word 'security' without careful evaluation, which could show that security is a subjective feeling; a 'secure' individual is merely one who feels safe from potential threats.

1.4. Complexity in Systems Engineering

The International Council on Systems Engineering (INCOSE) [**22**] states that: 1) a system is based on one's perspective on what system is and what elements and processes are required to accomplish objectives; and 2) systems engineering is defined as an interdisciplinary approach and means to enable the realisation of successful systems. In this case, a number of compete theories and approaches have been proposed to address various factors that are identified as the cause of system project failures restricting the realisation of successful systems [**50, 118, 241, 249, 297**]. Such causal factors have contributed to complexity, which is usually undesirable in systems engineering.

Complexity is defined as "the state or quality of being intricate or complicated" [**5**], which is omnipresent [**125, 156**]. It has been pointed out as the root cause of causal factors in system project failures [**118, 156, 255**]. According to Davis and Venkatesh [**122**, p.31], "the failure rate for newly developed systems remains unacceptably high, especially for large and complex... [t]he failure was amplified by project complexity". Thousands of project failures reported by Software Productivity Research (SPR) and the Standish Group were used to illustrate that the failure rate for system projects is unacceptably high and driven by complexity. In Al-Ahmad et al. [**50**, p.95], "Billions of dollars have been wasted on failed projects, and many highly expensive projects had to be shelved after a short time due to massive resistance from end-users. The cost of IT failure has skyrocketed in recent years as development projects have become more and more complex. The body of knowledge that resides in literature which addresses this phenomenon is enormous. A hundred or more factors attributed to projects' failure have been identified". In a paper by Daniels and LaMarsh [**118**], an application of SAP adopted by the Hershey Company was used to illustrate that all causal factors of failure in information technology project management are conditioned by complexity. This is supported by Normal Accident Theory [**280**] in which all causal factors are considered to be the primary cause of failure as life is a complex system.

Complexity is also perceived to be the root cause of problems in security engineering. According to Schneier [**301**, p.10], "complexity is the worst enemy of security". The author further emphasised that complexity can "lead to butterfly effects (minor problems getting out of hand)... [complexity] not only makes it virtually impossible to create a secure system, it also makes the system extremely hard to manage" [**301**, p.322]. Security is complex, since it relies upon the proper configuration of physical devices, such as firewalls, web servers, etc. If these physical devices are improperly configured, systems may become a target for fraudsters who can search for vulnerabilities arising from such misconfiguration. Security also relies on various mechanisms applied to physical devices to provide security services. For example, cryptographic mechanisms can be used to provide e-commerce systems with confidentiality,

integrity and authentication. Furthermore, security is complex because it is based upon trust relationships among participants (e.g. consumers and merchants in an e-commerce context) who are influenced by many social factors (culture, familiarity, etc.). In this case, complexity in security arises not only from technology, but also from businesses, economics and people. Schneier expressed his opinion about the complexity in another of his books, "As a security professional, I think complexity is terrifying. It leads to more and more subtle vulnerabilities. It leads to catastrophic failures, which are both harder to test for beforehand and harder to diagnose afterward. This has been true since the beginning of technology and is likely to be true for the foreseeable future. As systems continue to get more complex, they will continue to get less secure. This fundamental tension between ever more complex systems and security is at the core of many of today's security problems" [**300**, p.90].

1.5. Complexity in Buddhism

In Buddhism, complexity can be referred to situations when a perceived phenomenon is not consistent with our experiences and expectations. A system is complex because complexity is perceived from the system. Instead of treating complexity as a problem that must (somehow) be solved or overcome in order to enable the realisation of successful systems, Buddhism suggests that the starting point of a more appropriate path is to accept the reality of complexity rather than taking an adversarial stance toward it [**313**]. Complexity is the reality associated with all systems. A system in Buddhism is viewed as an indefinably gigantic system. A system cannot be identified except in relation to other systems which allow us to determine its *hetu* (causal relations) and *paccaya* (conditions). Any change in cause and conditions will influence the identity of a system. Anything that influences the identity of a system is considered as cause and conditions in Buddhism. For example, a system exists because there is a person who has ability to see the system at that particular time and place. There is also a person creating that system and there is also a person who brings the system to that place. There is a vehicle that delivers the system to that place. Cause and conditions are also extended to the families of these people. These families are those who give the people opportunity to survive in this world and become parts of the system's identity. Every system is just a representation of cause and conditions and nobody really knows the true identity of a system. Cause and conditions in Buddhism can be illustrated by causality or causation in Western Philosophy, which is "the relation between two items one of which is a cause of the other ... can also refer to a group of topics including the nature of the causal relation, causal explanation, and the status of causal laws" [**189**, p.131]. In modern philosophy, causality covers all aspects concerning something producing something else such as events. Any change in these causal factors will effect the identity of a phenomenon.

1.5.1. Inconstant Nature and Proximity Maintenance. Since a system is not a stand-alone property, but conditioned by cause and conditions, *anicca* (impermanence, inconstance, uncertainty) is the reality that all systems are inconstant (e.g., the absence of

continuity or the absence of permanence in a system). The reality is that all systems are inconstant and subject to change. While all systems are impermanent, inconstant, and uncertain, all individuals are anxious because of this uncertainty and the struggle to maintain *nicca* (permanence, constance, certainty) of the attached system. This certainty maintenance of the attachment phenomenon is comparable to proximity maintenance to the attachment figure in psychology, which is the desire to maintain proximity to the attachment figure perceived as a secure base [**85, 86**]. Although the attempt to maintain certainty of attachment can provide temporal stability of secure base for users to return to safe haven, this certainty maintenance of attachment is the root cause of *dukkha* (suffering). It is pointed out by Buddha as the root cause of sufferings. According to Ames [**53**, p.288],

> "Buddhists generally do not think that we need to invoke selves or essences to account for the continuity in our experiences. In fact, they emphasise that our tendency to try to hold on to things as if they had a permanent essence and to regard ourselves as real, enduring entities is at the root of our suffering".

1.5.2. Separation Distress and Attachment. A number of 'sufferings' have long been expressed in the literature when a system is not consistent with a desired state or expectations in systems engineering. In Buddhism, suffering is an inevitable condition that users eventually suffer from losing possessions to their attachments. This fear of losing possessions can also be described by separation distress in psychology [**85, 86**], which is anxiety that arises in the absence of the attachment figure. In terms of separation from the attachment figure, Ainsworth et al. [**47**, p.20-21] pointed out that "We all fear separation from attachment figures, but 'separation' cannot be defined simply as a matter of absence of such a figure. What is crucial is the availability of the figure". Bretherton [**91**] is also of a similar opinion about separation anxiety. When faced with separation from a parent, material object or any attachment object, individuals are bound to respond dramatically. Seperation distress is an attachment symptom, which is noticable in emotional expressions when there is an absence of an attachment figure. Stress prompts an individual to search a safe haven in the form of an attachment object. Distress is observed in cases where an individual is separated from an attachment object. Separation distress is acknowledged in both psychology and Buddhism as an observable symptom of attachment. While separation distress in psychology arises when proximity maintenance towards an attached object or a person is affected, the fear of losing possessions in Buddhism covers all four conditions of attachment. If any of these attachment conditions is affected, individuals may undergo different phases of defence mechanisms in order to maintain proximity bound to four types of attachment. Therefore, separation distress arises when the condition of proximity maintenance (certainty maintenance) associated with sensual pleasure, views, precepts or code of conduct and self towards a system is affected.

1.6. Organisation of the Thesis

The thesis investigates the condition of attachment in systems engineering and related disciplines. The thesis provides knowledge from Buddhist perspectives in order to analyse system project failures in a way that can be useful for research scholars and practitioners in systems engineering and related disciplines. Therefore, the thesis is divided into three parts, excluding this chapter. Part I, consisting of Chapter 2, 3, and 4, introduces the condition of attachment in systems engineering. Chapter 2 discusses positive influences of the condition of attachment that contribute to competitive theories and approaches to address complexity in systems engineering. In Chapter 3, negative influences of the condition of attachment in systems engineering that contribute to system project failures are discussed. The case of SET (Secure Electronic Transactions), which was labeled by security research scholars as the most secure electronic payment system, is used to illustrate how the condition of attachment was associated with how SET was predicted, how it was designed, and how it was failed to be implemented. In Chapter 4, the Dhammic framework, a theoretical framework from Buddhist insights, is established. The framework is a logical and novel framework that is based on the psychological conditions of an individual from Buddhist perspectives. The Dhammic framework logically represents psychological constructs underlying how a condition of attachment is derived, where a condition of attachment is situated and why a condition of attachment can be undesirable.

Part II, containing chapters 5 and 6, covers experiments on a condition of attachment derived from the Dhammic framework. This part is to confirm whether or not a condition of attachment in Buddhism can be useful in systems engineering. Chapter 5 starts from grounded theories related to system acceptance before emphasising TAM (Technology Acceptance Model), which has been a widely used model for predicting user acceptance of innovations. While TAM is based on certain psychological constructs for predicting behavioural intentions toward using a system, this chapter proposes Dhammic TAM (DTAM), which is based on TAM extended by the condition of attachment in Buddhism. This chapter also investigates if there exists other TAM extensions that may include a condition of attachment. How DTAM is distinct from those TAM extensions will be discussed. Chapter 6 contains the methodology (e.g., instrument development, participants, measurement, and procedures) to confirm if the condition of attachment can be considered to enhance the predictability of TAM. This chapter also contains all the experimental results with reference to DTAM. The results discuss whether or not the condition of attachment plays an important role in system acceptance and should be considered as a critical construct for predicting behavioural intentions toward using a system.

Part III, made up of chapters 7 and 8, covers recommendations, conclusions, and suggestions for future research. In Chapter 7, the notion of Middle Path (MP), which is also an insight of Buddhism, is recommendend as an appropriate path in systems engineering. Buddhist MP systems engineering is recommended to avoid offending users given that the

condition of attachment plays an important role in system acceptance. Systems engineering theories that support the notion of Buddhist MP systems engineering are also discussed in this chapter. Chapter 8, which is the last chapter, starts with a summary paragraph of the chapter structure and thesis. Then, this chapter discusses limitations of the research and future works that the condition of attachment in Buddhism may be applicable to in a systems engineering context.

CHAPTER 2

Positive Attachments in Systems Engineering

> "Engineering Systems are increasing in size, scope, and complexity as a result of globalization, new technological capabilities, rising consumer expectations, and increasing social requirements. Engineering Systems present [more] difficult design problem solving frameworks than those of the traditional engineering sciences paradigm: in particular, a more integrative approach in which Engineering Systems professionals view technological systems as part of a larger whole. Though Engineering Systems are varied, they often display similar behavior. New approaches, frameworks, theories, need to be developed to understand better Engineering Systems behavior and design", Roos [**293**].

2.1. Introduction

The previous chapter points out that the condition of attachment is always associated with how individuals view and deal with a perceived phenomenon such as complexity. Although most individuals attempt to address complexity in order to maintain their emotional attachment conditions to the phenomenon, Buddhism suggests that the phenomenon itself is not complex and separated from the condition of attachment. Instead, the condition of attachment should be paid attention in order to understand the reality of a perceived phenomenon. These two different views on complexity are consistent with two schools of thought on addressing complexity [**125**]: complexity an emerging phenomenon and complexity as an engineering problem. The first school views complexity as a phenomenon to be understood, while the latter school views complexity as a problem to be tackled. These views for addressing complexity have been applied in systems engineering in order to enable the realisation of successful systems. For instance, requirements engineering is an approach that adopts a multi-disciplinary view for addressing the poor quality requirements that influence the overall quality of a system's product [**62, 64, 89, 127, 163, 368, 372**]. Ignoring requirements engineering or getting it wrong may lead to cancellation of the project or extensive modification of the system [**144, 226, 339**]. A system quality model is recommended as an important framework for mitigating undesirable outcomes of system products [**95, 99, 244, 268, 350**]. In a more specific field of systems engineering, such as security engineering, the security aspects in the design of systems against potential threats are emphasised [**57**]. This chapter discusses these compete theories and approaches that have contributed to significant developments of knowledge and technologies in systems engineering. Please note that the term

'systems failure' in this thesis simply means a situation when a system fails to be implemented resulting from the system being rejected by end-users although there are different meanings than this in the systems engineering literature [**154, 249, 315**].

2.1.1. Requirements Engineering (RE). What is the definition of a requirement? IEEE Std 610.12-1990 [**200**] defines a requirement as "1) a condition or capability needed by a user to solve a problem or achieve an objective; (2) a condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed documents; (3) a documented representation of a condition or capability as in (1) or (2)". ISO 9000 [**193, 194**], a prominent standard family for quality management systems, defines a requirement as a "need or expectation that is stated, generally implied, or obligatory" [**194**, p.9]. In addition, requirements are classified into functional and non-functional requirements. Functional requirements are requirements in the 'solution domain' generally proposed by systems engineers that includes a description of components, including inputs, outputs, and behaviour that specifies what a secure system must do. Non-functional requirements are requirements in the 'problem domain' proposed by users, then evaluated by systems engineers as a description of criteria that specify what can be used to justify the system's operation [**339**]. Non-functional requirements are sometimes set out as performance or quality requirements [**197, 339**]. Guidelines for good quality requirement statements are briefly described in SoftwareProject.org [**12**]. For example, formal and precise words must be taken into account. Conjunctions such as 'and' and 'or' need attention. In order to ensure that requirements are understood and of high quality, verification and validation are recommended. However, Liu [**247**] claims that users' requirements could be wrongly interpreted and misunderstood by the analysts despite the fact they may have been represented in correct 'syntax'. Liu further claims that requirements are likely to be written by system developers, who may be unable to capture concerns of stakeholders correctly and completely. In this case, Liu proposes "common English language structure" to restructure requirement statements and capture the focus of quality requirements in Quality Functional Deployment (QFD). This technique is similar to the Natural Language Syntax and Semantics of Georgiades et al. [**161**] and the Natural Language Requirements Analysis of Gnesi et al. [**165**].

A number of requirements engineering approaches have been proposed in the literature to address poor quality requirements. In Sommerville [**318**], elicitation, analysis, validation, negotiation, documentation and management are fundamental to all RE process. Sommerville suggests that these fundamentals must always be cyclic due to uncertainty in the nature of RE. After requirements have been elicited and analysed, requirements engineers must validate and negotiate with users whether requirements are correct, consistent, and complete. The process of documentation and management of requirements is central to all steps in RE (see Figure 2.1.1).

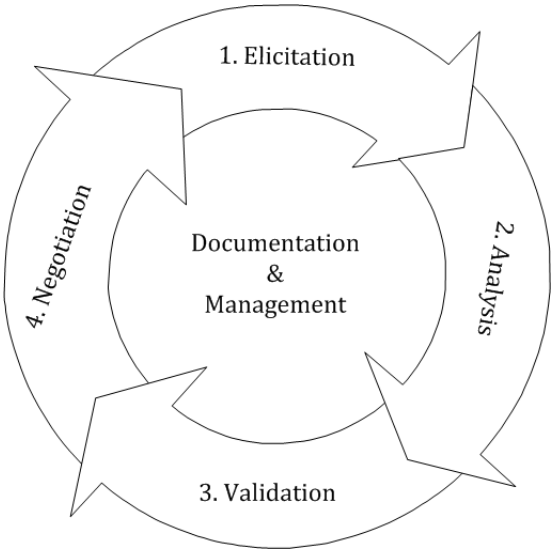

FIGURE 2.1.1. The Fundamental RE Process of Sommerville [**318**].

In order to validate requirements, Sukumaran et al. [**324**] point out that requirements are validated when the right set of requirements are correct, consistent, and complete. However, Firesmith [**146**, p.41] contends that "requirements will never be totally complete, finished, and finalized as long as a system is in service and must evolve to meet the changing needs of its customers and users". Firesmith points out that using correctness, consistency and completeness as quality evaluation criteria for requirements is not realistic. Requirements can be complete for only a particular period of time. The term 'validation' is also confused with 'verification' in systems engineering. According to Daintith [**117**, p.562], verification and validation are

> "generic term[s] for the complete range of checks that are performed on a system in order to increase confidence that the system is suitable for its intended purpose... Although a precise distinction is not always drawn, the verification aspect normally refers to completely objective checking of conformity to some well-defined specification, while the validation aspect normally refers to a somewhat subjective assessment of likely suitability in the intended environment".

The above quote is consistent with Bahill and Henderson [**64**], who assert that validation ensures the product actually meets the user's needs, and the specifications are correct in the first place, while verification is to ensure the product is built according to the requirements and design specifications.

Cheng and Atlee [**106**] note that understanding requirements is difficult, as they deal with the complicated nature of the uncertain requirements situated in the 'problem space'; whereas, other software engineering areas reside in the 'solution space'. They suggest that the state of the art in requirements engineering should comprise five main tasks: 1) elicitation (activities that enable the understanding of goals, objectives, and motives regarding a proposed system); 2) modeling (requirements or specifications that are expressed into one or more

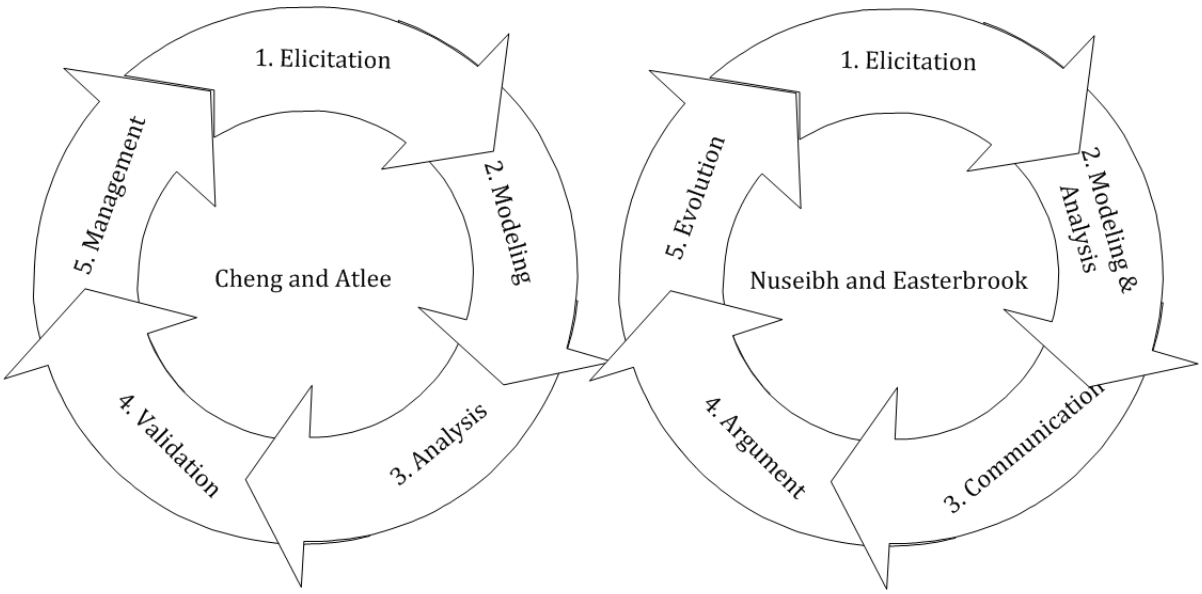

FIGURE 2.1.2. The State of Art of RE [**106**] and The RE Roadmap [**273**]

models in ways that are more precise than those in the elicitation stage); 3) analysis (new or improved techniques that are used to evaluate the quality of gathered requirements); 4) validation (techniques that are used to ensure that all expressed requirements in previous stages accurately meet stakeholders' needs); and 5) management (a number of tasks related to the management of requirements that can evolve from time to time). Cheng and Atlee's framework is not significantly different from Sommerville's in which major requirements activities, including elicitation, analysis, validation, and management, are still associated. However, Cheng and Atlee emphasise modeling based on requirements 'concretised' from the elicitation stage followed by analysis of appropriate technique for evaluating the model [**106**]. All five RE tasks should be cyclic until elicited requirements are complete.

The RE Roadmap proposed by Nuseibh and Easterbrook [**273**] is adapted from the framework of Cheng and Atlee. The RE Roadmap integrates modeling and analysis in a single stage. Instead of having a validation stage, like other frameworks, Nuseibh and Easterbrook suggest deploying communication, argument and evolution in the RE process (see Figure 2.1.2). The model of requirements would be the subject of discussion amongst stakeholders, then the model might evolve after that communication and argument. The Nuseibh and Easterbrook framework is similar to the 'rapid development methodology' in information systems in which the constructed model evolves throughout the communication life-cycle [**58**]. Although validation was excluded in the Nuseibh and Easterbrook model, it was associated with communication and argument prior to requirements evolution. If the participants involved in the project were satisfied, that implied validation had occurred. The process would move to the elicitation stage again if requirements issues remained.

A 'use case' is another requirements engineering technique in software and systems engineering that is widely discussed in the literature. It is intended as a way to avoid technical

words by using the end-user language [**149, 229, 317**]. A use case is a description of a system's behaviour when it responds to requests originating from outside of that system. The use case technique is commonly used to describe functional requirements of a system containing necessary interactions among actors throughout the system. It can be used to describe how a specific goal can be achieved when the system interacts with associated actors. While a use case defines the interactions between external actors and the system under consideration to accomplish a goal, an actor specifies a role played by a person or thing when interacting within the system. The same person using the system may be represented as two different actors because they are playing different roles. In Some [**317**] use cases and scenarios approaches were combined for functionality identification and system requirements validation. However, Wiegers [**360**] suggests five use case traps and contends that use cases are not appropriate for the entire process of RE because of potential complexity for stakeholders and limited features in representing requirements. In particular, Wiegers [**360**] emphasises that the use case technique may have been effective in representing functional requirements of a system, but, due to its technical representation, it does not represent what users really want.

However, Mishra et al. [**265**] argue that there is no particular technique in RE that can perfectly deal with all requirements stages. Instead of applying particular techniques similar to other RE frameworks, Mishra et al. propose that combining RE techniques is an effective approach for requirements elicitation and validation in situations where the requirements of stakeholders are heterogeneous. A benefit of using this RE combination technique is its flexibility. It is not restricted to a particular framework. Requirements engineers can select any step from different frameworks appropriate to their context. On the other hand, this approach may not be persuasive in an environment where standards are important. In addition, although RE approaches have been proposed to address poor quality requirements, Lawrence et al. [**234**, p.62] contend that "The worst thing that can happen in requirements engineering is that your set of requirements, however expressed, doesn't accurately represent your users' needs and consequently [they lead] your team down the wrong development path". The top risks of RE identified in the literature overlook a crucial requirement, inadequate customer representation, modelling only functional requirements, not inspecting requirements, and representing requirements in the form of designs. Such criticisms imply that requirements engineering is not only an approach for addressing poor quality requirements, but also an approach that causes poor quality requirements, and those influence the resulting quality of a system's product.

Although Hull et al. [**197**] argue that the fundamental 'quality' of a requirement is to satisfy the customer and ensure that the needs of all the stakeholders are taken into account, they are not realistic. Identifying stakeholders may be an important factor in improving quality of requirements and software quality [**276**]. However, definitions of stakeholder have varied from generic to specific. For example, Gurse et al. [**172**] provide a generic definition

that stakeholder that refer to individuals or groups of individuals. Bot et al. [**82**, p.152] state that stakeholders include "product choosers, end users, architects, system engineers, developers, maintainers, managers, executives, marketing personnel, to name a few". Different theories of stakeholders are described in Alexander [**52**], who proposes the onion diagram of product stakeholders. Alexander classifies stakeholders based on their positions and place in the 'onion layers' (mainly social, sociotechnical, and technical). The onion diagram is based on the author's perception of stakeholders' social positions.

2.1.2. System Quality Improvements. In addition to requirements engineering, how to improve quality of a system is another topic of discussion in the literature. There have been different views on system quality improvements in systems engineering when the term 'quality' is paid attention to as an essential factor that enables the realisation of successful systems. Cote et al. [**114**] stated that "[w]hile specific definitions have been established for given contexts, there is no consensus as to what constitutes quality in the general sense in software engineering". ISO 9000 definitions of quality vary from "whatever the customer perceives good quality to be" to "the degree to which a set of inherent characteristics fulfills the requirements" [**17, 193, 194**]. In Quality Management Framework (QMF) [**302**], quality is defined as "the degree to which an object (entity) (e.g., process, product, or service) satisfies a specified set of attributes or requirements". Cote et al. summarise the definition of quality as two aspects: 1) the concept of attributes; and 2) the satisfaction or degree of attainment of the attributes. IEEE Std 610.12 [**200**] defines quality in similar ways: 1) the degree to which a system, component, or process meets specified requirements; and 2) the degree to which a system, component, or process meets customer or user needs or expectations. IEEE defined a quality factor and attribute as "[a] feature or characteristic that affects an item's quality", but they distinguished between the two terms. They noted 'quality factor' should be used for higher level characteristics whereas lower level features should be called 'quality attributes' in a hierarchy of quality characteristics.

Notably, quality requirements in system quality models are different from the quality requirements in requirements engineering that are usually referred to as non-functional requirements. Quality requirements in system quality models are specified as quality attributes, quality properties, or quality characteristics. Although requirements are classified into functional and non-functional requirements, Hoyle [**193, 194**] concluded that all requirements should be considered as quality requirements. Quality requirements are considered by Firesmith [**147**] as the primary drivers of the system and subsystem architectures. While quality requirements should (in some authors' views) be objective, accurate, quantitative, and provide evaluation criteria [**15, 63**], Dromey [**132, 133**] asserts that quality is subjective and experiential in which people draw their own conclusions of whether something they use, encounter or examine is good or has 'quality'. This assertion is supported by Deming [**126**], who states that quality could be defined only in terms of the agent, the one who is the judge of quality.

The ISO 9126 Quality Model						
Internal and External Quality						Quality in Use
Functionality	***Reliability***	***Usability***	***Efficiency***	***Maintainability***	***Portability***	***Effectiveness***
suitability	maturity	understandability	time behavior	analysability	adaptability	productivity
accuracy	fault tolerance	learnability	resource utilisation	changeability	installability	safety
interoperability	recoverability	operability	efficiency	stability	co-existence	satisfaction
security	reliability	attractiveness	compliance	testability	replaceability	
functionality	compliance	usability		maintainability	portability	
compliance		compliance		compliance	compliance	

TABLE 1. ISO 9126 Quality Characteristics.

In order to ensure that a system meets specified quality requirements, a system quality model has become a research topic drawning a lot of attention in the area of systems engineering. Many system quality models were constructed based on the quality attributes that should be integrated in a system. A system then will be designed and constructed in accordance with quality attributes that are guided by the quality model. Quality models are proposed in different patterns based on perceptions of quality improvement (e.g., sets of quality characteristics, metrics, and process). Breivold and Crnkovic [**90**, p.18] state "a quality model provides a framework for quality assessment and aims to describe complex quality criteria through breaking them down into concrete subcharacteristics that are measured through metrics". According to ISO/IEC 9126-1 [**16**], a quality model is defined as "the set of characteristics and relationships between them, which provides the basis for specifying quality requirements and evaluating quality". Functionality, reliability, usability, efficiency, maintainability, and portability are key software quality characteristics of ISO/IEC 9126 for evaluating software in terms of internal quality, external quality, and quality in use [**16, 18, 19, 21**].

Conceptual Model Quality Framework (CMQF) [**244**] is an example of a quality model that classifies quality attributes into three main linguistic studies: 1) syntactics (quality attributes that connect model and language); 2) semantics (quality attributes that connect model and domain or relevant knowledge); and 3) pragmatics (quality attributes that connect model and audience interpretation). A Semiotic Quality Model proposed by Price is a successor of CMQF that has been implemented in a few cases of systems engineering [**284, 285**].

A System and Requirements Classification Model (SRCM) was proposed by Bahill and Henderson [**64**] to classify system quality at different levels. In the SRCM, verification and validation are two major criteria for system quality classifications that are allocated to different regions labelled A1 to C4. For example, A1 is assigned to a system where both requirements and system are verified or validated, while C4 is used when requirements are

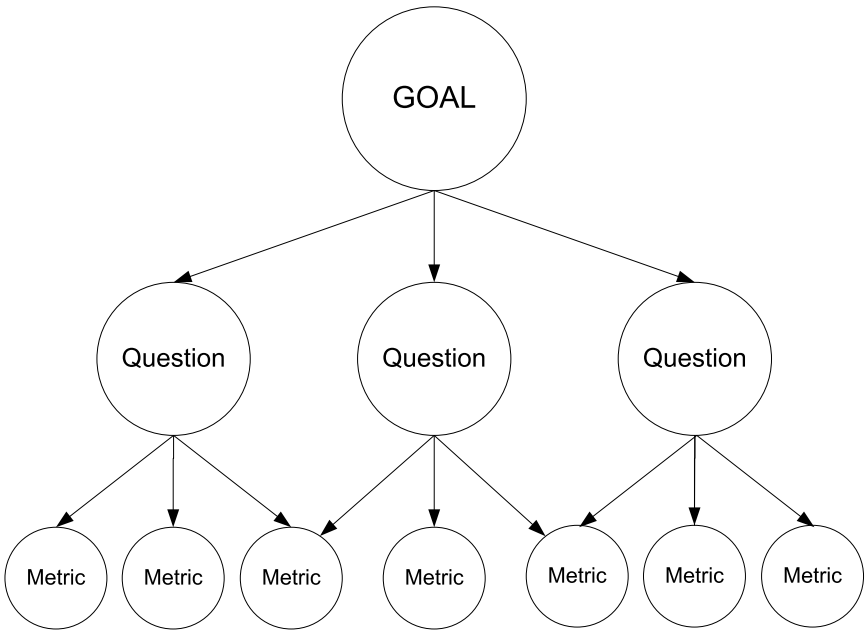

FIGURE 2.1.3. The GQM approach [**78**].

infeasible due to unavailability of supportive technologies. The SRCM is used by the authors to evaluate a number of famous failures in systems engineering (e.g., B1 was assigned to Edsel automobile and A2 was assigned to IBM PCjr). The potential region of each system quality is also included in the SRCM.

A model for software product quality proposed by Dromey [**132, 133**] contained five steps for refining a product quality model (i.e., identify high-level quality attributes, identify the product components, identify the most significant, tangible, quality-carrying properties, propose a set of axioms linking product properties to quality attributes, and evaluate and refine the model). In contrast, the Goal, Question, Metric (GQM) approach [**78**] defines a measurement model on three levels (i.e., conceptual level (goal), operational level (question), and metric (quantitative level). Goals, questions, and metrics are not pre-defined, but identified when conducting systems development. A goal is defined for a system for various reasons related to the quality of a system from different aspects with respect to a particular environment. A set of questions is constructed in accordance with the assessment or achievement of a specific goal. A set of metrics is established in accordance with constructed questions to provide measurable answers (for further details, please see [**78**]).

In addition to sets of quality characteristics, process quality improvement is also used as a system quality improvement model. Moody [**268**] considered a focus on product quality as an inefficient way of achieving quality, since it emphasised error detection and correction. In contrast, process quality was related to error prevention, mitigation and processes of error detection in final products. Process quality was claimed to eliminate 'root causes' of errors [**67, 268, 328**]. The 5 Whys [**6**] is a process quality improvement technique that originated

in Toyota. It was used in the 'Analyse' phase of the DMAIC (Define, Measure, Analyse, Improve, Control) of Six Sigma (6σ) [**160, 286, 287**]. DMAIC is a business quality control and improvement framework that uses various quality control and improvement methodologies (e.g., Quality Checklists, TQM, QFD, FMEA). Six Sigma covered many quality aspects from manufacturing to business processes. It focused on product quality improvement and process quality improvement. By repeatedly asking the question "Why" (five was recommended), problems could be identified which would lead to the identification of the root causes. Nevertheless, Paradies [**277**] points out limitations of The 5 Whys of Six Sigma and contends that the questions used to get into the root cause of problems could be biased, since these questions were shaped mainly by perceptions of system engineers. "For many years, quality improvement practitioners have been taught to find root causes of problems by using a set of tools based on the theory of cause and effect. These tools include the five whys and fishbone diagrams. Many users of these techniques, however, find that some problems, especially those caused by human error, keep happening" [**277**, p.33].

Furthermore, Barney and Wohlin [**67**, p.4] pointed out that "Software product quality can easily become an area of problems and conflict, as each stakeholder group has its own perspective on what is important". The authors also pointed out that relying on any quality model may be inadequate to cover essential quality attributes in the real context, since quality requirements of software products are often proposed from just a system engineer's perspective. This is consistent with Deming [**126**], who claimed quality models should be evaluated as representations of the "real world". Since quality requirements for a system are subjective, new quality models are likely to be proposed every year in response to newly perceived quality requirements. The proliferation of quality models has led to some confusion, according to Moody [**268**]. Moody considered more than 50 proposals related to quality models and also identified 12 research issues that arose from the proliferation of the proposals (see Table 2). In addition, the synthetic methodology for a quality model has "not yet been applied in a rigorous manner" for the study of the quality of software requirements [**268**]. Although there have been a number of quality models for evaluating the quality of software products, there is no equivalent standard for evaluating such models. The evaluation of quality models is usually based on common sense; subjective opinions and experiences normally conducted in an ad-hoc manner. In order to standardise quality models, Moody suggested ISO 9126 be used as a universal framework for specifying systems qualities.

Nevertheless, ISO/IEC 9126 has been widely criticised in the literature in terms of the selection of quality attributes. In Barney and Wohlin [**67**], major quality models such as Boehm's and ISO/IEC 9126 did not present a rationale for the selection of characteristics to be included in the quality model. Dromey [**132**] argued that it was infeasible to build high-level quality attributes, such as the reliability or maintainability specified in ISO/IEC 9126, into a software product. Instead, software developers should consider properties that assist to achievement of quality attributes. Bucur [**96**] claimed that most quality evaluation

No.	Issues	Description
1	Proliferation of proposals	Confusion for practitioners to use, barrier to research progress for establishing a common paradigm.
2	Lack of empirical testing	Few empirical validations (less than 20%).
3	Lack of adoption in practice	No wide acceptance in practice.
4	Different levels of generality	General proposals are from researcher's or engineers perspectives, specific proposals are usually from practice perspective.
5	Lack of agreement on concepts and terminology	Different terminology for the same concept (characteristic, attribute, property, etc.).
6	Lack of consistency with related fields and standards	Inconsistency with available international standards such as ISO 9126.
7	Lack of measurement	No guidance for measurement, subjective application.
8	Lack of evaluation procedures	Emphasis on quality criteria (what), but not quality process (how).
9	Lack of guidelines for improvement	Emphasis on quality evaluation (defect detection), but not quality improvement (defect correction).
10	Focus is on static models	Emphasis on data and information (static), but not functionality (dynamic).
11	Focus is on product quality (defect correction not prevention)	Emphasis on product quality (defect correction), but not process quality (defect prevention).
12	Lack of knowledge about real world requirements and practices	Emphasis on the evaluation of proposals, but not the reality in practice.

TABLE 2. 12 research issues in quality models, after [**268**].

standards used in software engineering were not up-to-date. Most needed revision to be consistent with the evolutionary requirements of the software engineering industry and of users. Suryn et al. [**326**] also argue that there is a lack of quality-related measurement instruments that facilitate quality engineering throughout the entire software product life cycle. Several

standards have been used for software quality engineering, but none is applicable throughout the software product life cycle. Although the ISO/IEC 9126 series included a quality model, characteristics, sub-characteristics, and measures necessary for the process of quality measurement, proper guidance for quality evaluation were still missing. ISO/IEC 9126 was not sufficient to be used as a universal quality model, since it emphasised quality characteristics, but not a quality evaluation process. It was suggested that ISO/IEC 9126 should be integrated with other ISO/IEC related quality evaluation standards in order to facilitate the quality evaluation process, e.g. with ISO/IEC 14598 (software product evaluation) as described in Cote et al. [**114**], ISO/IEC 15939 (systems and software engineering – measurement process) as in Abran [**41**], and ISO/IEC 15288 (systems and software engineering – system life cycle processes) as in Suryn et al. [**326**].

Although ISO/IEC 9126 and ISO/IEC 14598 series have been discussed in the literature as potential standards for quality requirements evaluation, ISO/IEC 25000, namely Software Product Quality Requirements and Evaluation (SQuaRE) has emerged as a better solution. It is the new series of ISO/IEC. It contains more quality evaluation standards and covers what is set out in ISO/IEC 9126 and ISO/IEC14598 [**26**]. ISO/IEC 25000 series comprises five divisions: 1) ISO/IEC 2500n (Quality management division); 2) ISO/IEC 2501n (Quality model division); 3) ISO/IEC 2502n (Quality measurement division); 4) ISO/IEC 2503n (Quality requirements division); and 5) ISO/IEC 2504n (Quality evaluation division). A valuable feature of ISO/IEC 25030 (a submit of SQuaRE) [**26**] is a new standard on software quality requirements developed to assure quality requirement perspectives in software development. As briefly introduced in [**77**], ISO/IEC 25030, section 6 (necessary aspects of quality requirements) emphasises quality requirement aspects in both problem and solution domains such as (6.2) stakeholder quality requirements and (6.3) software quality requirements.

2.2. Security Engineering

While a system itself is universal and consists of a number of sub-systems, various aspects of the system have been emphasised in systems engineering literature. Security engineering, for example, is one of the most popular disciplines in software and systems engineering that has received widespread attention from researchers and practitioners. Although security engineering is a specific field of systems engineering, competing theories and approaches in this field seem to be almost as numerous as those in systems engineering. While the term 'security' is defined in a general context as "the state of being free from danger or threat" [**13**], ISO/IEC 27001 [**24**] defines security as "all about protecting and preserving information. It's all about protecting and preserving the confidentiality, integrity, authenticity, availability, and reliability of information". Security is perceived by security experts as either a feeling or reality. According to Oppliger [**275**, p.11], "Security is a subjective feeling that is perceived differently by different people. What somebody considers to be secure may be considered by somebody else to be completely insecure". There are a number of security researchers, who

believe that security is all about perceptions. Nicholson [**272**, p. 11], for example, claims that "Security is a state of mind, without which all else is a waste of time and resources". This is consistent with Thomborson [**340**, p.3], who suggested that "a system is *secure* if its owner ever estimated its probable losses from adverse events, such as eavesdropping". However, Schneier [**300**, p.9] argues that "security is both feeling and reality". This author distinguishes that security as a state of mind is used when we feel secure and protected from harm, while security as reality has nothing to do with how we feel.

In order to build a secure system, there are different views on how a secure system should be designed against potential threats. Barak [**66**], a prominent security researcher, classifies security engineering into "well-defined security" and "fuzzy security". Well-defined security is used to describe any secure system that is well constructed and therefore provable (e.g., digital signatures, PKI or public-key infrastructure). In contrast, fuzzy security, is related to any secure system that is constructed with vague claims about security algorithms. Fuzzy security does not require rigorous definition of security nor a rigid statement of security properties. If there is a case of security vulnerability, the algorithm can be "tweaked" by either the security engineer or users to provide a better perception (and reality or outcome) of security. Barak [**66**] argues that well-defined specifications are actually much more important in security than in other areas of software engineering. Under well-defined specifications, the security of a system can eventually become perfect depending on a matter of time and repetition of testing and scrutiny. Security experts who support extreme views of well-defined security tend to believe that the world will become ready to invest for well-defined security if the defects of fuzzily-secure approaches become obvious.

Nevertheless, Schneier [**301**], another prominent security expert, is in favour of fuzzy security. Schneier claims that a real-world system is a complicated series of interconnections and many of them are not recognized by system engineers and users insecurities always exist [**301**]. Fuzzy security is Schneier's preferred approach, "security is never black and white, and context matters more than technology" [**301**, p.19]. Should a company invest in well-defined security? Schneier argued that "The costs of ignoring security and getting hacked have been, in the scheme of things, relatively small. We in the computer security field like to think they are enormous, but they have not really affected a company's bottom line" [**301**, p.12]. Given this, Schneier believed designers of secure systems should make them (i.e. the systems) as simple as possible.

2.2.1. Security Requirements Engineering. A significantly increasing number of reported application vulnerabilities (from 171 in 1995 to 5,590 in 2005 as reported by the Software Engineering Institutes's CERT (Computer Emergency Response Team) Coordination Center) indicated that appropriate security engineering approaches were required [**175**].

According to Weiss and Mouratidis [**355**], ad-hoc security requirements are used as security goals for various types of security patterns. This notion of ad-hoc security requirements is similar to Rossebo [**294**], who stated that "security requirements are well-defined, detailed

descriptions of how the high-level objectives are achieved". For example, the 'CIA' acronym standing for confidentiality, integrity, and availability, is widely referred to in the literature. It is a major set of computer security requirements. The precision of security requirements depends upon the complexity of the system. When a system is more complex (e.g., more participants involved), CIA may be insufficient to cover all aspects of security requirements. In e-commerce, for example, Hassler [**179**] pointed out that authentication and non-repudiation were two further security requirements in addition to CIA. Particularly, the authentication requirement that is used to ensure 'claimed to be' aspect has been added and connected to an 'authorisation' aspect that ensures information cannot be accessed and modified by unauthorised subjects but is still available to authorised subjects.

Accountability is considered as a security requirement, since it ensures that the communication is recorded [**24**]. Access control has also been suggested as a security requirement that covers authentication and authorisation. It is related to the ability to permit or deny a particular entity the use of a particular resource. Anderson [**57**] also included incentives as a major component in a security engineering model. When security is strongly connected to privacy, some security experts [**299**] pointed out that privacy no longer means anonymity; instead, it concerns how people's private communication and financial information can be protected properly. Privacy is therefore considered an essential security requirement. The notion of security as 'pain' [**231**] (where the acronym of 'PAIN' means privacy, authentication, integrity and non-repudiation) [**131, 256**] has also been discussed in the literature when security in a PKI context is emphasised [**216, 245**]. While most security requirements are identified in various attributes, Haley et al. [**174**] classed security requirements into: 1) security functions (functions and practices as defined in well-known information security standards such as ISO/IEC 15408 – Security Techniques – Evaluation Criteria for IT Security, NIST); 2) non-functional requirement (NFR) (restrictions or constraints on system services); 3) privacy and trust; and 4) high-level security goals and policies.

However, Tondel et al. [**342**] argue that although ad-hoc security requirements have been widely studied in the literature, they do not represent security requirements in the real world. Security requirements engineering, extended from RE, has been proposed to capture security requirements in the real world [**180**]. Although RE approaches are applicable to security requirements (i.e., functional security requirements are 'what the system should do'; while non-functional security requirements are 'what the system should be' [**281**]), they cannot be covered fully by general requirements engineering approaches. Security requirements are more specific than generic system requirements. As argued by Crook et al. [**116**, p.203], "a typical requirements engineering process will often generate conflicting or inconsistent requirements that have nothing to do with security". In this case, a number of security requirements engineering approaches have been proposed to improve quality of security requirements. Usage-centric Security Requirements engineering (USeR) [**176**] is an approach that consists of five steps: 1) identify security-related statements (from text-based descriptions of

	Confidentiality	Integrity	Availability
What?	What is the critical information for this process which should be confidential?	What is the critical information for this process which should be always accurate and reliable?	What is the critical information for this process which should always be available?
Why?	Why this information should be confidential?	Why this information should be accurate and reliable?	Why this information should always be available?
How?	How will the business be affected if the information does not remain confidential?	How will the business be affected if the information is unreliable?	How will the business be affected if the information is not available when needed?
Who?	Who is responsible for the confidentiality of this information?	Who is responsible for the integrity of this information?	Who is responsible for the availability of this information?
Where?	Where do you store this information ensure its confidentiality?	Where do you store this information ensure its integrity?	Where do you store this information ensure its availability?
When?	When does the confidentiality of this information become critical?	When does the integrity of this information become critical?	When does the availability of this information become critical?

TABLE 3. Business impact analysis for business process [**219**, p.249]

system requirements and statements that may have been expressed in informal language); 2) determine security needs (extracted from security-related statements by security experts and the systems developers); 3) determine security requirements (extracted from security needs by security experts); 4) determine security techniques (identified by security experts according to security requirements); and 5) explore design implications (by security experts and the system developers using concepts derived from the security techniques).

The notion of Six Honest Serving Men [sic] (SHSM); — what, why, how, who, where, and when — has also been used in a security requirements engineering approach, e.g. Enterprise Security Architecture applied by Sherwood [**311**] and Enterprise Architecture defined by Zachman [**370**]. Pinsent [**282**] pointed out how the Kipling's SHSM can be used in practical research. The author also mentioned that the Kipling's SHSM is quite effective for obtaining preliminary results in security requirements engineering. Kadam [**219**] applied Kipling's SHSM to information security policy development and implementation. The six key elements were employed to identify what the author believed important, including policy, executive decision, threats, vulnerability. Kadam provided examples of security requirements engineering using the SHSM by measuring threats and vulnerability with the CIA.

Confidentiality Requirements Elicitation and Engineering (CREE) is another security requirements engineering approach that emphasises confidentiality [**172**]. This approach

emphasises the role of stakeholders in establishing (or setting) explicit confidentiality requirements in the first place. Confidentiality requirements are generated into functional requirements where functional requirements will be allocated in social context. Confidentiality goals of different stakeholders can be accommodated by identified confidential functionalities.

In order to identify potential threats to a system, 'attack trees' and a 'misuse case' are two techniques that have been widely discussed in security engineering. Attack trees involves analysis of potential threats and then classification of them into a tree structure. In contrast, a misuse case technique is based on a use case technique, which is widely used in requirements engineering [**143**]. The misuse case describes potential threats using the notion of use cases, i.e., identifying potential threats by considering each action in each use case. Identified potential threats can be used to deduce what policies are important to prevent or mitigate those threats. Sindre and Opdahl [**316**] describe a misuse case technique as an extension of a use case technique but one which describes a negative scenario of a use case with hostile intent. The technique is useful for understanding undesirable behaviours of the system.

Tondel et al. [**342**] note in favour of a misuse case that the misuse case technique is more effective for identifying undesirable behaviours of the system than the 'attack trees' approach, e.g., the risk of neglecting essential security requirements is frequently discovered in the 'attack trees'. Particularly, the misuse case in-detail diagram is a key aspect that is superior to 'attack trees' for threat analysis. Two relationships between use and misuse cases were described by Tondel et al. [**342**]; potential countermeasures against misuse cases can be understood from use cases while vulnerability can be seen from misuse cases.

Besides eliciting security requirements, agreement on definitions is pointed out by Mellado et al. [**30**] as an important stage that should be taken into account. Mellado et al. suggest that most processes in security requirements engineering can be simplified once such security definitions have been agreed by stakeholders. Mellado et al. [**30**] point out that security requirements engineering approaches vary in their levels of rigour. Many approaches emphasise security requirements elicitation stages, but not agreement on definitions. This is supported by Abuosba et al. [**42**], who suggest that comprehensive attention to security requirements is essential at an initial stage of a security engineering methodology. Clear definitions of security concepts are important in security requirements engineering. Abuosba et al. [**42**] further mention that well-structured security requirements engineering methodologies are essential in software development life-cycles, since they represent paths for constructing secure systems for the project participants. In this case, Security Quality Requirements Engineering (SQUARE) appears to be a security requirements engineering approach that covers the requirements above. SQUARE developed at Carnegie Mellon University by Mead with Firesmith and Woody of the Software Engineering Institute (SEI) in the mid 2000s [**108, 168, 259, 260, 261, 365**] is one of very few security requirements engineering methodologies that provides a means of engineering security requirements in a structured manner. Integrating security considerations into the early stages of the development life cycle is the

long-term goal of SQUARE. SQUARE provides a means for eliciting, categorizing and prioritizing security requirements for information technology systems and applications. Case studies of SQUARE implementation can be obtained from [**108, 168**].

2.3. Summary

All theories, frameworks, and approaches in addressing complexity in systems engineering have been discussed. While a condition of attachment is central to our perceptions toward a phenomenon, these compete theories and approaches are arguably positive products of the condition of attachment. They have played a significant role behind innovations in systems engineering, e.g., requirements engineering approaches proposed to address poor quality requirements, quality frameworks proposed to improve the quality of a system, security engineering theories and approaches proposed to ensure the system could provide the required level of security, etc.

However, it is not always the case that products of attachment are positive, given that a system is subjectively perceived. A particular system quality attached by a system engineer may not be perceivable for a user. Furthermore, the degree of attachment condition is also varied among individuals despite the same attachment phenomenon. Although a particular system quality is perceived by both a system engineer and a user, there is a difference in the degrees of attachment associated with the quality perceived from a system. As such, the condition of attachment can be undesirable when its degree becomes extreme. This undesirable condition of attachment can be escalated when a particular quality perceived from a system is negatively attached and influences how a system is viewed. When there are view contradictions between a system engineer and a user, they may attempt to maintain certainty or proximity of their different attached possessions. A case of system project failures will be discussed in the next chapter in order to represent how the condition of attachment can be considered as a key factor underlying system project failures.

CHAPTER 3

Negative Attachments in Systems Engineering

> "One of the most common and least beneficial attitudes among software developers is "dogmatism". That is, each engineer "believes" in a particular paradigm, technique, tool, language, operating system, etc., which is seen as a remedy to all the problems of software construction", Juristo et al. [**218**, p.1].

3.1. Introduction

We learnt from chapter 1 that attachment is a condition that always underlies how individuals perceive and react to a phenomenon. The condition of attachment is central to our belief and behaviours although it is unnoticed by the perceiver. It is central to all belief systems and considered as the root cause of sufferings in Buddhism. In systems engineering, the condition of attachment has been associated with theories and approaches proposed to enable the realisation of a successful system. In other words, all contributions in systems engineering are driven by the condition of attachment. However, the condition of attachment can also be undesirable in systems engineering, which can contribute to system project failures. In Buddhism, the condition of attachment underlies *ditthi* (dogmatism) [**158**], which is a negative form of attachment. This negative form of attachment pointed out by the lord Buddha as a condition that everyone should be mindful of has also been cautioned in Western science. According to White [**357**, p.527], "Dogmatism is really a general thesis giving conditions for perceptual justification". Dogmatism is about differences in the nature of belief systems which simultaneously serve a need to understand the social world and a need to protect individuals from potentially threatening ideas and information [**238, 292**]. Dogmatism is defined as the tendency to lay down principles as undeniably true, without consideration of evidence or the opinions of others [**7**]. Johnson [**214**] states that

> "Dogmatism is the practice of pronouncing one's beliefs with rigid, arrogant certainty, absolute certainty...[d]ogmatism is the practice of clinging to any dogma (or cluster of tenets) that is presumed to have authoritative power. People can be dogmatic about belief systems around religion, politics, marriage and the family, gender relations, and other cultural attitudes and traditions".

Dogmatism is also pointed out as "the greatest threat to social, political, and scientific progress" [**215**, p.26]. Dogmatic individuals tend to have their impressions of others on less

information than those individual, who are not dogmatic [**290**]. A "lack personal insight" is pointed out as a significant characteristic of dogmatism [**357**].

When systems engineers attach to their views about how a system should be engineered, one's opinion about a system typically reveals a contradictory opinion from another. Systems engineers can become dogmatic and rely on what they believe can address problems. When system engineers are dogmatic and not satisfied with a particular quality of a system, they can become perfectionist, who refuse to accept any standard short of perfection" [**11**]. Although perfectionism can make software developers successful and appreciative by their boss, customers and colleagues, many system engineers have suffered from the disease of perfectionism [**25**]. System engineers are likely to ignore other qualities and be deceived into a cycle of particular quality improvement in which the end point is never reached. System engineers can be distracted from primary objectives and that may lead to delay in project completion time. These cycles are described as 'rat holes' in [**202**], and they may cause several undesirable outcomes (Figure 3.1.1). Dogmatic systems engineers are also likely to ignore 'value' for the users of a system, and that is critical to system project success and failures [**92**].

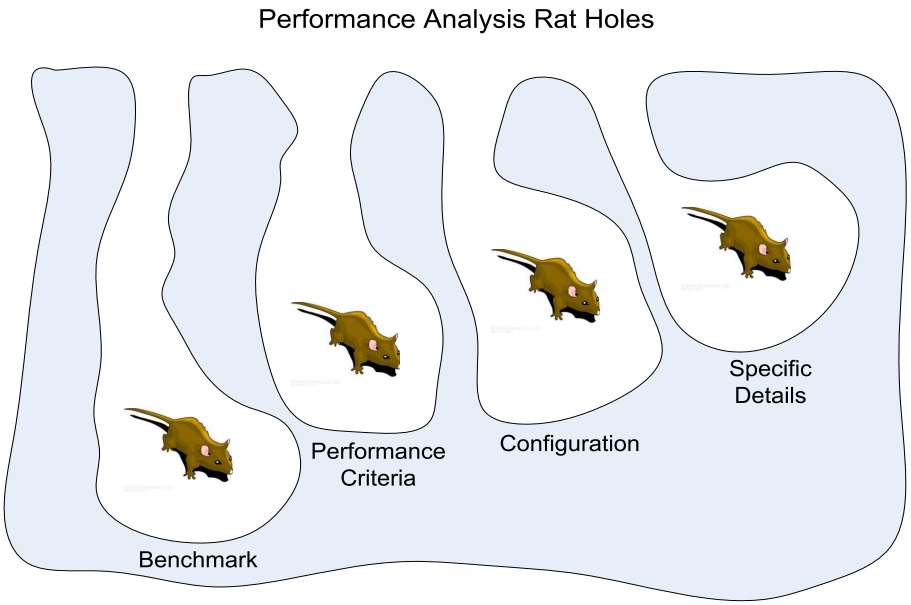

FIGURE 3.1.1. Performance Analysis Rat Holes, adapted from Jain [**202**]

This chapter discusses the condition of attachment associated with a case of system project failures. A case study of SET failures is used to illustrate how the condition of attachment plays an important role and contributes to undesirable outcomes in systems engineering. Different from other theories and approaches in the literature, this chapter focuses on how the cause of system project failures can be caused by internal factors. Since the thesis attempts to provide completely novel knowledge for analysing system project failures from Buddhist insights, there is no concrete and direct evidence supporting that system project

failures are driven by the condition of attachment. As such, a condition of attachment in the form of belief systems associated with how SET was predicted, designed, and failed to be implemented will be discussed in this chapter. Much of this chapter is based on publications [**203, 204, 205, 206, 208, 209, 210, 211**] where the author of this thesis is the prime author.

3.2. E-Commerce Security and PKI

When e-commerce was introduced as an alternative shopping method, a number of research scholars believed that the growth of e-commerce relied on a number of security-related factors [**75, 98, 103, 141, 157**] although e-commerce provided many benefits to consumers (e.g., convenience, greater choice, lower prices and more information). Hoffman et al. [**186**, pp.80-81] stated that part of "the consumer lack of trust arises from the fact that cyber-consumers feel they lack control over the access that Web merchants have to their personal information during the online navigation process ... consumers may fear typing in credit card information to any commercial Web provider". In order to address e-commerce security requirements, well-established cryptography was believed to be a 'magic pill'. An apparently secure e-commerce website would, in theory, convince potential e-commerce customers to become regular e-commerce customers. According to Giff [**162**], "[a]n example of increasing security to increase trust comes from people being more willing to engage in e-commerce if they are assured that their credit card numbers and personal data are cryptographically protected". In this light, PKI (Public Key Infrastructure) [**43**] was believed by security researchers and practitioners as a solution to e-commerce security and privacy concerns.

PKI is defined as "the entire set of functions necessary to support and operate a Public Key Hierarchy" [**170**, p.205]. According to Farrell and Zolotarev [**140**], PKI is vital for e-commerce security, since many applications that use PKI are not Web services and PKI is the only choice available for connecting business relationships to keys and identities when more than one domain is involved. In addition, Piper [**283**, p.24] stated that "Security is obviously a major concern for all potential users of E-commerce and the use of (public key) cryptography is an important issue". PKI is the subject of standardisation by a number of bodies, including the IETF, ITU-T and ISO/IEC. PKI is the infrastructure necessary for wide-scale use of public key cryptography (PKC) [**263, 266**]. It supports a variety of practically valuable cryptographic operations, including encryption, digital signature and entity authentication.

The use of PKC requires all parties to have their own key pair, made up of a public key (usually widely distributed) and a private key (known only to its owner). Verifying a digital signature, or sending encrypted data, requires possession of a trusted copy of the public key of the creator of the signature or of the intended recipient of the encrypted data. The trusted distribution of public keys is the key purpose of a PKI. A PKI usually contains of one or more Trusted Third Parties (TTPs) called Certification Authorities (CAs) [**185**]. A

CA creates public key certificates, where a certificate is the concatenation of the name of an entity (the subject of the certificate) with the public key of that entity (and other data), all signed using a private digital signature key owned by the CA. If a third party possesses the CA's public key (often called a 'root key'), then this can be used to verify the certificate and hence obtain a trusted copy of the subject's public key. In general, a PKI consists of a set of CAs, the set of certificates they have generated, the policy under which the certificates were issued, and various other parties (and protocol interfaces) involved in supporting the generation, management and distribution of public key certificates.

3.3. Secure Electronic Transactions (SET) – Overview

SET is a security protocol for an electronic payment system. It was invented by Visa and MasterCard in 1996 [**248, 264**]. A number of reputable IT organisations participated in SET developments (e.g., GTE, IBM, Microsoft, Netscape and Verisign). SET employs both symmetric and asymmetric cryptography to protect purchasing information sent between SET participants, including customer, merchant, the acquirer, and the issuer. Key management for SET is based on the use of a PKI to reliably distribute public keys between SET participants. SET supports long key lengths for both symmetric and asymmetric encryption, such as triple DES and 1,024-bit RSA [**304**]. SET was designed to address the limitations in the security provisions for e-commerce that were not being fulfilled by Secure Socket Layer/Transport Layer Security (SSL/TLS) protocol [**289**]. A number of security experts predicted that SET would become a standard for e-commerce payment system [**103, 104, 322**]. SET had "the potential to become a dominant force in assuring secure electronic transactions. SET provides an open standard not only for protecting the privacy but also for ensuring the authenticity, of electronic transactions" [**104**, p.22].

When SET was first introduced in 1996, it was believed by security experts to be widely used within two years [**275**, p.120]. SET'use was predicted to flourish in the future, since it would be supported by software, hardware, or even coexist with SSL/TLS. Asokan and Phillipe [**60**, p.35] predicted in 1997 that "Within the next two to three years, SET will become the predominant method for credit card purchases on the Internet. It will be implemented initially in software only, but will later be supported by smart cards. For some time, the currently preferred method of using SSL to encrypt payment details on their way from payer to payee will coexist with SET". Security mechanisms of SET were predicted to be a key enabler of global use of e-commerce. According to Merkow et al. [**264**, p.1], "Secure Electronic Transactions (SET) will help make the new 'industrial revolution' a reality in the 21st century, this time without smokestacks or assembly lines...[t]he fact is, SET now provides the mechanism to unleash explosive and unlimited global commerce the likes of which the world has never before seen".

Since SET technologies were designed to support PKI, the use of PKI solutions was also expected to be widely used as a standard mean for e-commerce security as a result of implementation of SET. According to Birch [**14**, p.454],

> "One of the first 'mass' market uses of public key certificate infrastructure is being driven by the implementation of the Secure Electronic Transaction (SET) standard. In the near future, payment card holders who want to use their cards online will be issued with SET certificates. This means that banks are developing capabilities and infrastructure with interesting implications, but they're not the only people with an interest in the emergence of a such an infrastructure and it won't be long before an entirely new business sector emerges around the use of public keys and digital signatures".

3.4. Security Architecture of SET

As PKI was believed as a solution to e-commerce security and privacy concerns that could not be fulfilled by SSL/TLS, SET architecture was designed to support PKI technologies. The following are SET technologies designed to support PKI.

3.4.1. Mandatory Digital Certificates. SET enforces the use of digital signatures to authenticate identity of customer and merchant in order to mitigate the risk of information being manipulated by a malicious third party. In the SET scheme, Certificate Authority (CA) issues digital certificates to the issuing bank or 'the issuer' ($CERT_{ISS} = Sign_{(SK_{CA})}[PK_{ISS}]$) and the acquiring bank or 'the acquirer' ($CERT_{ACC} = Sign_{(SK_{CA})}[PK_{ACC}]$). The issuer and the accuirer also play important roles in issuing digital certificates that are mandatory in the SET scheme. Customers must apply for digital certificates from their issuing bank ($CERT_{CUS} = Sign_{(SK_{ISS})}[PK_{CUS}]$), whilst the acquiring bank will be responsible for issuing digital certificates for merchants ($CERT_{MER} = Sign_{(SK_{ACC})}[PK_{MER}]$) [**304, 305**]. In order for customers to obtain digital certificates, SET requires the customer to have been through an initialisation process. For example, an asymmetric key pair for the customer must be generated. Then, the e-consumer's public key must be sent to the customer's bank ('the issuer'), which generates a public key certificate for the customer using the issuer's private signature key. The system 'root' public key will be distributed to the customer, along with the customer's public key certificate. The customer's private key will be stored in a 'digital wallet' on the customer's PC, which typically will be password-protected.

3.4.2. Dual Signatures. SET ensures the confidentiality and privacy of purchasing information at all stages of transaction processing, including data transmission and data storage. In the SET scheme customer purchasing information is classified into order and payment information (OI and PI) [**248, 264**]. Both OI and PI are encrypted with separate public keys. Merchant public keys are used to encrypt OI ($E_{(PK_{MER})}[OI]$), and acquiring bank public keys are used to encrypt PI ($E_{(PK_{ACC})}[PI]$). This is to make sure that the encrypted

OI can only be decrypted by the merchant and the encrypted PI can only be decrypted by the acquiring bank. Merchants will only be able to access OI, whilst PI will be forward directly to the acquiring bank in encrypted form. In addition to confidentiality protection, the integrity of OI and PI is also covered by well-cryptographic mechanisms of SET. If there was unauthorised access to a merchant's web server, the confidentiality of consumer PI would not be affected.

3.4.3. Digital Wallet. SET was designed to ensure the merchant obtain cardholder authentication as part of an e-commerce transaction. SET enforces customer self-authentication. They perform this on their local PC by entering a password that activates their digital wallet prior to initiating a transaction. The customer's PC then transmits OI and PI, encrypted with separate public keys, to the merchant $Sign_{(SK_{CUS})}\{E_{(PK_{MER})}[OI] \mid E_{(PK_{ACC})}[PI]\}$ [**248, 264, 304, 305**]. In addition, SET was designed to protect against repudiation of a transaction by having the issuing bank and the acquiring bank both play a crucial role in verifying the transaction. The issuing bank will provide a payment authorisation (PA) to the acquiring bank once the cardholder has been authenticated and agreed the payment. Similarly, the acquiring bank will inform the merchant once the PA has been provided by the issuing bank. Due to having both issuer and the acquirer involved in verifying each transaction, SET transactions are approved by major financial institutions such as Visa and MasterCard as 'card present' transactions. An overview of the interaction among the participants in SET transaction can be briefly described below.

(1) $C \rightarrow M : SET_{request}$ (The cardholder requests SET initialisation from the merchant).
(2) $M \rightarrow C : SET_{response}$ (The merchant responds SET initialisation to the customer).
(3) $C \rightarrow M : Sign_{(SK_{CUS})}\{E_{(PK_{MER})}[OI] \mid E_{(PK_{ACC})}[PI]\}$ (The cardholder submits and signs OI and PI encryped by the merchant's public key and the acquirer's public key respectively).
(4) $M \rightarrow A : (E_{(PK_{ACC})}[PI]$ (The merchant forwards PI encrypted by the acquirer's public key to the acquirer).
(5) $A \rightarrow SET_{gateway} \rightarrow I : PA_{request}$ (The acquirer requests payment authorisation from the issuer via SET payment gateway).
(6) $I \rightarrow SET_{gateway} \rightarrow A : PA_{response}$ (The issuer responds payment authorisation to the issuer via SET payment gateway).
(7) $A \rightarrow M : PA$ (The acquirer sends a payment authorisation to the merchant).
(8) $M \rightarrow C : PA_{confirmation}$ (The merchants confirms and captures the transaction).

3.5. Complexity of SET

Although the security properties of SET were superior to SSL/TLS in preventing potential e-commerce fraud [**345**], SET was not implemented due to its complexity. The elegant security architecture of SET caused a number of significant problems. PKI solutions that were expected to be a 'magic pill' for e-commerce security issues instead became 'toxic'. A number

of criticisms were leveled at SET. These varied from poor usability to the vulnerability of PKI. According to Bellis [**71**, p.79], "the amount of overhead involved in the massive Public Key Infrastructure (PKI) and registration process required by SET, [means] it will never be widely adopted". That author further points out that adding the extra overhead of a PKI infrastructure was not appropriate for the payment process at that time. This view is also supported by Treese and Stewart [**343**], who argues that use of PKI in SET was not compatible with the existing e-payment infrastructure (of the 1990s), since SET prevented merchants from seeing consumer credit card numbers.

The use of PKI also made SET initialisation complicated. In particular, key pairs needed to be established for each entity (and public keys certified) [**320**]. This criticism is reinformed by Lieb [**240**, p.2], who claimed that "the effort to obtain digital certificates has held up deployment of SET technology". In addition, operation of SET required special software to be installed by both customers and merchants, there were more tasks for customers and merchants to implement SET than those of SSL/TLS. This made SET initialisation more complicated, on top of the already complex requirements for obtaining digital certificates. Since a private key had to be stored in a digital wallet installed on a customer PC, using password protection was not considered secure enough [**152, 306, 307**].

The complexity of SET also made e-commerce transactions slow [**207, 209**]. According to Whinnett [**356**, p.449], "Insufficient speed also discourages on-line shopping and creates the danger that users will interrupt transactions if they are not implemented quickly enough". The low speed and high complexity of transactions was a common criticism of SET, and these properties reduced its attractiveness to both merchants and consumers. SET was also inflexible, since digital wallets needed to be present in the consumer's PC in order to address potential misuse of credit card numbers [**289**]. Although many software vendors were developing and standardising digital wallets in order to make it easier for consumers to use them (e.g., the MasterCard wallet based on IBM wallet v2.1 [**199**] supported both the SET and SSL protocols), consumers were still required to obtain digital wallets and set up their digital certificates and credit card details into the wallets.

While there were a number of PKI interoperability issues, interoperability among SET products was also a significant problem of SET. This included certificate translations among trusted third parties (TTPs) that had different certificate policies. These sets of rules and understandings are almost inevitably different, which means that interpreting a certificate issued as part of a different TTPs becomes very problematic.

3.6. Attempted Solutions to SET Problems

After SET experienced significant resistance from e-commerce participants, SET developers still believed that the wide adoption of SET was feasible. Several SET extensions were introduced in order to address complexity and facilitate greater adoption of SET [**203, 208**],

including the PIN [**307**], chip [**306**], and server-based wallet extensions [**199**]. However, these extensions were still designed to support PKI technologies.

3.6.1. SET/EMV. PIN and Chip extensions were proposed to address SET problems related to the secrecy of private keys. By integrating SET with PIN extensions, the vulnerability of a private key entirely protected by a password was addressed. PIN extensions provided authentication process. By integrating SET with Chip extensions, the storage location of a private key would be protected by security features of IC. PIN and Chip extensions contributed to SET/EMV, a new project of SET integrating with the EMV industry standards (named after the three responsible organisations: Europay, MasterCard and Visa International), [**137, 179, 310**]. The EMV Specifications defined how compliant IC cards and payment terminals should interact. These specifications were established to enable IC cards to be used to replace existing credit and debit magnetic strip cards, without requiring a separate merchant terminal for each card brand. Like SET, EMV employed a PKI mechanism to support the provision of confidentiality and integrity for transactions.

In the EMV card authentication scheme, an issuer provides each IC card with its own private/public key pair. Each card will also contain a digital certificate for the card's public key, signed by the issuer's private key. In addition, issuer public keys are certified by a brand Certification Authority (CA), set up by the owner of the card brand (e.g. Visa or MasterCard). The appropriate issuer public key certificate is then put on the card, along with the card public key certificate. In addition, the brand CA public keys are loaded into every merchant terminal. This then enables a merchant terminal to verify the pair of certificates held by the IC card. In turns this enables the merchant to verify the IC card's digital signature [**138**]. The integration of SET with EMV can simplify the complication of SET initialisation (e.g. there is no need for the cardholder to establish SET-specific keys and then apply for a digital certificate).

SET/EMV was proposed to reduce the complexity of SET end-user initialisation, but retain SET's security features [**208**]. There is no need for consumers to generate a key pair specifically for SET, since the key pair and certificates already contained in the EMV smart card can be used instead. SET/EMV addresses flexibility problems by allowing consumers to purchase products or services from any PC that has a smart card reader and the appropriate software installed. SET/EMV also addresses problems of the security of private keys, since the private key is no longer stored on the consumer's PC. However, SET/EMV was still rather complicated for consumers since it required an additional device (an IC card reader) to be connected to the consumer's PC. Major SET-required components and complex cryptographic mechanisms were still required for SET/EMV. Merchants were still required to invest in a point-of-sale (POS) application to allow communications from the cardholder via the SET scheme. The POS application was also needed in order to communicate with the payment gateway installed at the acquiring bank's server.

3.6.2. 3D SET. 3D SET is a product of server-based wallet extensions [**199**] that is based on three-domain (3D) architecture [**364**]. With the server-based wallet, all consumer functionality (including the digital wallet software and the digital certificate) is securely implemented on the card issuer's server. Implementing the wallet and the cardholder certificate at the level of card issuer addresses implementation issues with SET, since it eliminates both the need to download wallet software to every cardholder and the requirement for a cardholder to obtain a digital certificate. The server-based wallet concept was also extended to the merchant, enabling the payment gateway and merchant certificates to be kept at an acquirer server. In this case, 3D SET was built upon the relationships between three 'domains': 1) acquirer (the relationship between the merchant and the acquiring's bank); 2) issuer (the relationship between the cardholder/consumer and the issuer); and 3) interoperability (the acquirer and issuer domains are supported by the interoperability domain) [**83, 364**]. Among the three domains, a URL redirection technique was used to enable communications.

3D SET replaced the traditional SET digital wallet that must be stored on a consumer's PC with a SET Wallet Server in the issuer domain [**211**]. Instead of having the customer's certificate stored on the customer's PC, the certificate is stored on the issuer's secure server. The customer does not need to generate his/her own key pair and obtain a certificate, since all this is taken care of by the card issuer. In the meantime, the acquirer stores the merchant's certificate and implements the payment gateway at the acquirer secure server. This makes merchant initialisation simple, since the acquirer takes care of key management and certification for the merchant. As with similar to SET/EMV, major SET-required components and complex cryptographic mechanisms were also required for 3D SET. However, consumers did not require an additional device.

3.7. SET Failures — MasterCard SPA and Visa 3-D Secure

Although SET/EMV and 3D SET should be capable of rectifying several significant problems found in conventional SET, SET developers were unable to convince e-commerce participants of this. The SET products were not widely implemented. The only surviving element from SET development was the concept of 3D architecture. It had nothing to do with PKI, but contributed to the emergence of other electronic payment systems such as MasterCard SPA and Visa 3-D Secure [**169**].

SET, which was belived by security experts as the most secure payment system, caused insecure attachments among e-commerce participants. SET was rejected because of certainty maintenance that e-commerce participants maintained their secure feelings by rejecting potential threats. In other words, SET was perceived by e-commerce participants as a potential threat that might harm their secure feelings.

3.7.1. MasterCard SPA. MasterCard SPA (Secure Payment Application) [**169**] was a 3D-architecture-based e-payment system proposed by MasterCard after the failure of SET.

Since MasterCard SPA was not based on the use of PKI, several major problems of SET were no longer relevant.

In order to conduct MasterCard SPA-based e-commerce, an issuing bank had to participate in the transaction by having SPA server installed on their side. At the same time, MasterCard SPA required customers to have the SPA applet installed on their PCs, in a similar fashion to a SET digital wallet. The applet could be obtained from various distribution channels (e.g., floppy disk, CD-ROM, and Internet). The SPA applet is a light applet; it is only required for SPA-based merchant initialisation and credit card authentication with the issuer SPA server. It differs from the SET digital wallet; there were no requirements to have PKI components (e.g., private key and private key) installed on the applet. Although automatic form-filling of the SPA applet was pointed out as a function that makes MasterCard SPA more competitive than Visa 3-D Secure, the enforcement of having the SPA applet installed on the PC was pointed out as a significant disadvantage. MasterCard SPA was discontinued just few years after it was proposed as an alternative secure e-payment system.

3.7.2. Visa 3-D Secure. Visa 3-D Secure (Verified by Visa or VbV), originally known as 3D SSL [**203**], is an e-payment system based on the three-domain architecture used by 3D SET. Visa 3-D Secure can be regarded as the integration of SSL with the 3D architecture. Visa 3-D Secure was proposed to address SSL/TLS problems where absense of verification of the cardholder can result in credit card fraud at the consumer side. Visa 3-D Secure provides e-commerce merchants with cardholder verification, whilst still retaining the 'ease-of-use' associated with use of SSL/TLS.

In Visa 3-D Secure, the payment gateway must be implemented in the acquirer domain [**347**]. This gateway provides an interface between the merchant/acquirer's payment system and the Visa proprietary payment network VisaNet. Merchants are just responsible for installing an SSL/TLS Merchant Plug-In (MPI) at their servers, in the same way they would implement SSL/TLS. The MPI has additional functions to handle communication with a centralised Visa directory. To provide communication between the various entities, Visa 3-D Secure simply uses a URL redirection technique to enable communication that is protected using SSL/TLS among entities within the three domains: cardholder-merchant, cardholder-ACS, merchant-Visa Directory, and Visa Directory-ACS [**203, 347**].

The issuer needs to maintain a special server known as the Access Control Server (ACS). The ACS is used to support cardholder authentication. This enables the merchant to authenticate the cardholder, and obtain a signed guarantee from the Issuer ACS that the cardholder was present during the transaction. Merchants are provided with evidence, in the form of a message signed by the Issuer ACS, that the cardholder was present and the Issuer has authorised the transaction. This gives the merchant protection against the possibility of a 'card-not-present' chargeback. The Visa directory, a server in the Interoperability domain, enables communication between merchant servers and card issuers.

Since the primary use of PKI is not required, problems found in SET do not apply to Visa 3-D Secure. SET-required components for customers and merchants and its complex cryptographic functionality became redundant with the emergence of Visa 3-D Secure. Visa 3-D Secure imposes minimal overheads on end-users, since it is based on SSL/TLS and the only step required of the user is to register for the service with their card issuer (e.g., using a web registration procedure). Visa 3-D Secure benefits the merchant because it preserves the payment model used for existing SSL/TLS-protected e-commerce transactions and because it works well and easily. The initialisation is simple for both merchant and customer, especially for those already experienced in SSL/TLS. The merchant simply needs to install a special plug-in on his/her server, and the cardholder needs no special software. They must simply follow an on-line enrolment process with the card issuer, using a 'standard' web browser. The following numbered sequence of steps summarises the operation of Visa 3-D Secure [**203**].

(1) $C \rightarrow M : CR, \{PI\}_{SSL|TLS}$ (The cardholder submits a checkout request (CR) to the merchant. All purchasing information (PI) transmitted to the merchant server will be protected by SSL/TLS).
(2) $[MPI \mid M] \rightarrow VDir : URR, PI$ (After the purchase information has been transmitted to the merchant server (M), the MPI at the merchant server sends a URL request (URR) to the Visa directory for the URL of the ACS of the issuer of the card).
(3) $VDir \rightarrow I : URR$ (The Visa directory checks the validity of the card and queries its participation in the 3-D Secure scheme with the ACS at the issuer server (I)).
(4) $I \rightarrow VDir : CM, URL$ (The issuer sends a confirmation message (CM) and the URL to the Visa directory confirming the validity of the card details).
(5) $VDir \rightarrow [MPI \mid M] : URL$ (The URL of the issuer's ACS is sent to the MPI from the Visa directory).
(6) $[MPI \mid M] \rightarrow C \rightarrow [ACS \mid I] : PVR$ (The MPI redirects the cardholder browser to the issuer's ACS for payment verification request (PVR)).
(7) $[ACS \mid I] \rightarrow C : SAR$ (The issuer's ACS requests secret authentication (SA) information, such as username and password, from the cardholder).
(8) $C \rightarrow [ACS \mid I] : \{SA\}_{SSL|TLS}$ (The cardholder enters his/her SA into the browser on his/her PC, from where it is sent to the issuer's ACS).
(9) $[ACS \mid I] \rightarrow C \rightarrow [MPI \mid M] : Sign_{(SK_{ISS})}[PV]$ (If the cardholder validation process is successful, the issuer's ACS redirects the cardholder browser back to the MPI and sends a payment verification (PV) signed by the issuer).
(10) $M \rightarrow A : TD, PAR$ (The merchant transmits transaction details (TD) to the acquirer to request payment authorisation (PA) as in a 'normal' Internet transaction).
(11) $A \rightarrow I : PAR$ (The acquirer sends a payment authorisation request (PAR) to the issuer via Visanet).
(12) $I \rightarrow A : PA$ (The issuer responds by sending a PA to the acquirer).
(13) $A \rightarrow M : PA$ (The acquirer sends the PA details back to the merchant).

(14) $M \rightarrow C : TC$ (The merchant confirms the transaction (TC) and issues a receipt to the cardholder).

3.8. Discussion

A case of SET failures was used to illustrate how SET was designed and rejected by e-commerce end-users. In the meantime, it was also used to represent how the condition of attachment is associated with SET failures. The use of PKI in SET attached by security experts as a solution to e-commerce security and privacy concerns contributed to many problems which restricted users to adopt SET.

Although attachment is not a condition that can be simply used to ask "how much do you attach to a system", its proximity or certainty maintenance symptoms can be noticeable. All attempts and actions in order to maintain pleasurable sensual experiences, views and theories, rules and rituals, and belief in self and wordings are noticeable symptoms of the condition of attachment. To summarise this point, a system is predicted, designed, implemented, and rejected because of the condition of attachment. A number of efforts to address SET problems sought to reduce SET complexity while maintaining its security architecture is also an example of certainty maintenance. For example, SET extensions designed to support PKI technologies implies that SET developers still attached to elegant security features of PKI. Another example of certainty maintenance can also be seen from when SET was rejected by e-commerce participants although several significant problems of SET could potentially be addressed by evolutionary SET products such as SET/EMV and 3D SET. E-commerce participants attached to negative features of SET and rejected SET in order to maintain their emotional attachments. No matter how well a system is revised, it is not appreciative if e-commerce participants still attach to negative features of the system.

When the user attaches to sensual experiences perceived from the system such as freedom or comfort, any change or neglect of users' attachment may result in undesirable outcomes because the user will maintain certainty of his/her freedom in different ways if the freedom is affected. This notion of freedom maintenance can be illustrated by a theory of security and emancipation widely discussed in critical security studies [**79, 80, 270**]. According to Booth [**79**, p.319], "Security means the absence of threats. Emancipation is the freeing of people (as individuals and groups) from those physical and human constraints which stop them carrying out what they would freely choose to do... security and emancipation are two sides of the same coin. Emancipation, not power or order, produces true security. Emancipation, theoretically, is security". Based on Booth's theory, one of the major problems of SET adoption is because of emancipation issues. E-commerce end-users felt insecure attachment to adopting SET due to concern about their freedom being constrained (e.g., freedom to control their own computer affected by the enforcement of digital wallets and digital certificates). Security engineers have been attempting to construct a secure system for users, but they tended to ignore this desire for a fundamental human security. In other

words, the security engineer is also a cause of security issues. The notion of emancipation is similar to what expressed by Anderson [**54, 55, 56**] regarding Trusted Computing that general computer end-users are concerned about the ultimate control of their PCs and they will be very frustrated if they cannot control their own computers.

The condition of attachment is undesirable in systems engineering when the users feel insecure attachment to a system and defend against that system in order to maintain certainty of their emotional attachments. This temporal stability of user insecure attachment can remain until system engineers can no longer continue their efforts to maintain certainty of their attached views on the system. Finally, withdrawing from the system project may be the only solution for removing all obstacles. This negative attachment of users can be explained by the notion of first impressions, which can be positive or negative. Some may claim that the first impression is a last or binding impression. Although some may argue that the first impression may not be a lasting impression, but changing the first impression is rather difficult. If there is a negative first impression, systems engineers may need to work hard in order to overcome the negative first impression. This is consistent with the result of a number of experiments discussed by Robbins [**290**] that found negative first impressions of liking and character were more resistant to change than were positive first impressions. Changing a disliked person into a liked person is more difficult than changing a liked person into a disliked person.

3.9. Summary

Attachment is a condition that can contribute to desirable or undesirable outcomes in systems engineering. The condition of attachment has not been previously studied in the literature as a primary cause of system project failures. This chapter has pointed out that the condition of attachment is worthy of consideration in systems engineering projects because it suggests ways in which a system engineer and a user perceive will perceive, think, and deal with a system in order to maintain their attachments – even if these attachments are causing the project to fail. Although the condition of attachment can contribute to system project success such as innovations, this condition can contribute to undesirable outcomes in systems engineering such as system project failures.

A case of SET failures was used to illustrate how the condition of attachment could become part of system project failures. SET was designed to address security problems in e-payment systems perceived to be the most significant barriers restricting the growth of e-commerce. SET security architecture was based on PKI believed by security experts as a potential magic pill for e-commerce security problems. If the main purpose of security engineering is to build a dependable system that addresses security requirements [**57**], then SET appeared to be the most appropriate e-payment system for securing e-commerce transactions.

However, the use of PKI in SET contributed to many problems which restricted users to adopt SET. E-commerce end-users were not willingly to adopt SET because of several usability issues. Particularly, they refused to adopt SET when they were enfored to comply with SET security requirements. Although several significant problems of SET could potentially be addressed by SET/EMV and 3D SET, they were not convincing for e-commerce participants. Removing SET security architecture appeared to be the only solution for removing all SET problems. In other words, SET was no longer a magic pill, but something undesirable for e-commerce end-users. This chapter has pointed out that system project failures are resulted from unsolvable conflicts between systems engineers and users, who are possessed by different attachments.

While Buddhism is a well-constructed philosophy that has been widely used for describing psychological constructs, it would be worthwhile if such constructs can be logically used to explain how a phenomenon is perceived and becomes attached. As such, a theoretical framework will be constructed to describe these conditions in the next chapter. Please note that the framework will not directly address attached views of system engineers, but provides insights that may help system engineers understand how users actually perceive and use the system from Buddhist perspectives.

CHAPTER 4

The Dhammic Framework

> "the external world is only a manifestation of the activities of the mind itself, and that the mind grasps it as an external world simply because of its habit of discrimination and false-reasoning... the world has no self-nature, that it is unborn, that it is like a passing cloud, like the moon reflected in the ocean, like a vision, a mirage, a dream", Buddha [**166**, p.117].

4.1. Introduction

This chapter proposes the Dhammic framework, a logical, novel, and original framework, that is based on psychological conditions of an individual from Buddhist perspectives. The framework is constructed from Buddhist *Dhamma* in Pali or *Dharma* in Sanskrit (the teachings of Buddha that deal with problems in several aspects, such as metaphysics, phenomenology, ethics and epistemology). The Dhamma contains 84,000 Buddhist doctrines collected into *Tipitaka* (three baskets of teachings), including *Vinaya-Pitaka* (the basket of discipline dealing with rules and regulation of monastic life), *Sutta-Pitaka* (the basket of subject dealing with teachings and sermons of Buddha in different places), and *Abhidhamma-Pitaka* (the basket of insight dealing with philosophical and psychological discourse and interpretation of Buddhist doctrine). *Tipitaka* is primarily based on two languages, including Pali and Sanskrit. Pali is mainly used for *Theravada* (the 'Doctrine of the Elders') and Sanskrit is widely used for *Mahayana* (the 'Greater Vehicle') [**97**]. Since the author is a Theravada Buddhist, a number of terminologies in Pali from different doctrines will be used throughout this chapter with English translation in parentheses. States of mind described in the *Paticca Samuppada* (condition genesis, dependent origination, dependent arising, dependent co-arising, interdependent arising) doctrine will be used to represent an individual's mind to a system. The doctrine is widely referred to in 'mindfulness meditation', which is about recognising your thoughts and actions in the present without judging. The framework describes how a system migrates through a user's states of mind, including attachment discussed in previous chapters as a condition that underlies system project success or failures. The framework will also explain how the condition of attachment can lead to undesirable outcomes in systems engineering.

While the Buddhist Dhamma itself is extensive and has been subjectively interpreted, formalism technique will be used to identify discourses within text in order to avoid ambiguity and understand what is going on in the doctrines precisely [**267**]. In this case, Schemata of the Z notation [**201, 319, 363**], a formal specification language named after Zermelo–Fraenkel

set theory, will be used to describe states of mind in Buddhism. Community Z Tools will be used for Z syntax validation that we use to describe Buddhist state of mind discourses. The Dhammic framework represented in Z notation expresses important aspects of the Dhammic theory of perception, from initial contact to more complex cognitions and emotions. This framework could be used by a future cognitive computing system to describe how the perceptions of a collection of human users evolve as they gain experience with a collection of systems – where a "system" is defined to be any aggregation of matter, information and energy that some human perceives to be a persistent entity that is distinguishable from other systems. Much of this chapter is based on recent publications by Jarupunphol and Thomborson [**212**] where the author of this thesis is the prime author.

4.2. The Dhammic Framework

Citta (heart, mind) is mentioned in various Buddhist doctrines. In mindfulness meditation, the meaning of citta can be very specific. In the Dhammic framework, citta simply means a perceptual and cognitive element that represents an individual's mindset, or state of mind. In this case, the Dhammic framework will be used to represent how a system is perceived and cognised by a user. The Dhammic framework is based on two major schemata: 1) state schemata (the state schema provides a static view of a state of mind that includes components, or state variables, of the condition) and 2) operation schemata (the operation schema specifies how the state schema can be changed by taking an instance of the state schema and producing a new instance).

4.2.1. Sanna. *Sanna* (cognition) is a condition of mind that is related to the short-term and long-term memory of knowledge and experiences regarding a perceived phenomenon. The state schema $SANNA$ will provide a static view of all psychological conditions, including *phassa*, *rupa*, *nama*, *vedana*, *tanha*, *upadana*, *cetana*, and *kamma*. The $SANNA$ state schema is used to declare psychological conditions. The upper part of the schema consists of variable declarations of the mind. $SYSTEM$ and $USER$ are two basic type definitions where $system$ is a variable of $\mathbb{P}\, SYSTEM$ and $user$ is a variable of $\mathbb{P}\, USER$. Since the framework is based on a user's perception to a system that changes over time, we use $perception$ as a partial function from $USER$ to $SYSTEM$ to represent a relationship that maps each element of $USER$ to, at most, one element of $SYSTEM$. Other functions of psychological conditions are also defined in the same manner as the partial function $perception$.

The lower part of the schema consists of logical statements which define the perception. The set $user$ is to be a subset equal to the domain of the $perception$ function and the set $system$ is to be a subset equal to the range of the $perception$ function. All perceptual functions are defined as subsets equal to the partial function $perception$.

$$
\begin{array}{|l}
\hline
\textit{SANNA} \\
\hline
user : \mathbb{P}\, USER \\
system : \mathbb{P}\, SYSTEM \\
perception : USER \rightarrowtail SYSTEM \\
rupa : USER \rightarrowtail SYSTEM \\
nama : USER \rightarrowtail SYSTEM \\
vedana : USER \rightarrowtail SYSTEM \\
tanha : USER \rightarrowtail SYSTEM \\
upadana : USER \rightarrowtail SYSTEM \\
cetana : USER \rightarrowtail SYSTEM \\
kamma : USER \rightarrowtail SYSTEM \\
\hline
user \subseteq \operatorname{dom} perception \\
system \subseteq \operatorname{ran} perception \\
phassa \subseteq perception \\
rupa \subseteq perception \\
nama \subseteq perception \\
vedana \subseteq perception \\
tanha \subseteq perception \\
upadana \subseteq perception \\
cetana \subseteq perception \\
kamma \subseteq perception \\
\hline
\end{array}
$$

The initialisation schema *INIT* is created to set an initial stage before a user and a system make contact. Two variables, including *user* and *system* are set at $\emptyset$ in the first stage when a user has not yet perceived a system. There is no user and no system in the first state. In other words, there is no cognition about the system at the beginning.

$$
\begin{array}{|l}
\hline
\textit{INIT} \\
\hline
\Delta SANNA \\
\hline
user = \emptyset \\
system = \emptyset \\
\hline
\end{array}
$$

4.2.2. Phassa. *Phassa* (contact) refers to an initial state of mind when a human and a phenomenon make contact. The *PHASSA* is an operation schema that includes the state schema $\Delta SANNA$. This means the schema *SANNA* will be used with both its declarations and predicates. The operation schema *PHASSA* updates the component *phassa* in the schema *SANNA*. The upper part of the schema consists of variable declarations in which $u?$ (defined as *USER* type) and $s?$ (defined as *SYSTEM* type) are two emerging elements (or input arguments) in *user* and *system* respectively. The lower part of the schema, *PHASSA*, consists

of logical statements of phassa. The $u? \notin \operatorname{dom} phassa$ predicate is a pre-condition; it defines conditions which must hold when the operation starts. The pre-condition is used to represent the inconstant state of a phenomenon that a new system state is always perceived.

The predicate $phassa' = phassa \cup u? \mapsto s?$ is post-condition of phassa, used to represent an element $u?$ has been updated in $user$ ($user' = user \cup u?$) and an element $s?$ has been updated in $system$ ($system' = system \cup s?$) by $phassa$. Please note that any similar predicate clarified in this section will not be explained further for other states of mind.

$$
\begin{array}{|l}
\hline
\textit{PHASSA} \\
\Delta SANNA \\
u? : USER \\
s? : SYSTEM \\
\hline
u? \notin \operatorname{dom} phassa \\
phassa' = phassa \cup \{u? \mapsto s?\} \\
\hline
\end{array}
$$

4.2.3. Rupa.

> "Monks, forms are inconstant, changeable, alterable. Sounds... Aromas... Flavors... Tactile sensations... Ideas are inconstant, changeable, alterable", Rupa Sutta [**29**].

Rupa (form) is a condition that occurs when the external properties of a phenomenon are represented in human perception. It refers to a state of mind to physical properties of a phenomenon that are based on the combination of four elements, including solidity, fluidity, motion and heat (understood by Buddhism as soil, water, wind, and fire). If there is no contact between a human and a phenomenon, no meaning can be perceived. *Rupa* is comparable to primary qualities in Western philosophy that are related to physical properties or extrinsic features of objects represented in perceptions [**61**]. *Rupa* is an observable property of a system that directly interacts with a user.

The $RUPA$ is an operation schema that includes the state schema $\Delta SANNA$. The operation schema $RUPA$ updates the component $rupa$ in the schema $SANNA$. The predicate $u? \mapsto s? \in phassa$ in the lower part is a pre-condition; it defines conditions, that a user and a system must have already been contacted when external properties of a system are perceived. For example, a user can perceive external properties of a system only after the user and the system have contacted($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \in rupa \Rightarrow u? \mapsto s? \in phassa$). In the meantime, if the user and the system have not contacted, then the user cannot perceive the external properties of a system($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \notin phassa \Rightarrow u? \mapsto s? \notin rupa$).

$$
\begin{array}{|l}
\hline
\textit{RUPA} \\
\Delta SANNA \\
u? : USER \\
s? : SYSTEM \\
\hline
u? \mapsto s? \in phassa \\
u? \notin \operatorname{dom} rupa \\
rupa' = rupa \cup \{u? \mapsto s?\} \\
\hline
\end{array}
$$

4.2.4. Nama. *Nama* (formlessness) is a condition that occurs when qualities of a phenomenon are represented in human perception. This condition arises after external properties of a phenomenon have been perceived. If a phenomenon is not perceived, there is no meaning that can be perceived from it. *Nama* can be described by secondary qualities in Western philosophy that are related to qualities or intrinsic features of objects that are represented in perceptions such as smell, taste, sound, colour, and warmth or cold. Any plausible qualities that can be perceived directly from the external properties of a system are *nama*. *Nama* is comparable to the qualities that are directly influenced by the external properties of a system. Perceived qualities are not stand-alone, but dependent upon perceived external properties. A number of perceived qualities have been defined by system engineers as different factors (e.g., usability, security, reliability, etc.).

The *NAMA* is an operational schema that includes the state schema $\Delta SANNA$. The operation schema *NAMA* updates the component *nama* in the schema *SANNA*. The predicate $u? \mapsto s? \in rupa$ in the lower part is a pre-condition; it defines conditions, that external properties of a system must have been perceived when the qualities of a system are perceived. For example, a user can perceive qualities from a system only after the user perceives its external properties ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \in nama \Rightarrow u? \mapsto s? \in rupa$). In the meantime, if a user does not perceive the external properties of a new system state, then he or she cannot perceive its qualities ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \notin rupa \Rightarrow u? \mapsto s? \notin nama$).

$$
\begin{array}{|l}
\hline
\textit{NAMA} \\
\Delta SANNA \\
u? : USER \\
s? : SYSTEM \\
\hline
u? \mapsto s? \in rupa \\
u? \notin \operatorname{dom} nama \\
nama' = nama \cup \{u? \mapsto s?\} \\
\hline
\end{array}
$$

4.2.5. Vedana.

> "Monks, feeling born of eye-contact is inconstant, changeable, alterable. Feeling born of ear-contact... Feeling born of nose-contact... Feeling born of tongue-contact... Feeling born of body-contact... Feeling born of intellect-contact is inconstant, changeable, alterable", Vedana Sutta [**31**].

Vedana (feeling, sensation) is a condition of attitudes toward a phenomenon that occurs after qualities of a phenomenon have been perceived. If a quality of a phenomenon is not perceived, there is no attitude toward a phenomenon. *Vedana* is the initial level of attitude that can be immediately noticed by a user. It refers to three plausible attitudes to a quality perceived from a phenomenon, including *sukha* (positive feelings such as like, satisfactoriness, pleasantness), *dukkha* (negative feelings such as dislike, unsatisfactoriness, unpleasantness), and *uppekha* (neutral, neither sukha nor dukkha) [**309, 361**]. All these attitudes will not arise without being influenced by perceived qualities.

In this case, *VEDANA* is a state schema that includes the state schema $\Delta SANNA$. As *sukha*, *dukkha*, and *uppekha* are types of *vedana*, their functions are also defined in the same manner as the partial function *vedana* in the schema *SANNA*. The lower part indicates that all three attitudes are subsets equal to *vedana*. A user can feel positive, negative, or neutral to a system at the time of each perception ($\forall\, u? : user \mid \exists\, s? : system \bullet u? \mapsto s? \in sukha \lor u? \mapsto s? \in dukkha \lor u? \mapsto s? \in uppekha \bullet sukha \cap dukkha \cap uppekha = \emptyset$).

$$
\begin{array}{|l}
\hline
\textit{VEDANA} \\
\Delta SANNA \\
sukha : USER \nrightarrow SYSTEM \\
dukkha : USER \nrightarrow SYSTEM \\
uppekha : USER \nrightarrow SYSTEM \\
\hline
sukha \subseteq vedana \\
dukkha \subseteq vedana \\
uppekha \subseteq vedana \\
\hline
\end{array}
$$

4.2.5.1. *Sukha. Sukha* is a condition that occurs when the attitude toward a system is positive. The *SUKHA* is an operational schema that includes the state schema $\Delta VEDANA$. The operation schema *SUKHA* updates the component *sukha* in the schema *VEDANA*. The predicate $u? \mapsto s? \in nama$ in the lower part is a pre-condition; it defines conditions that a user must have perceived in a system quality when the *sukha* operation arises as a state of mind. For example, a user's positive attitude toward a system arises only after the user perceives the qualities of a system ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \in sukha \Rightarrow u? \mapsto s? \in nama$). In the meantime, if the user's positive attitude toward a system does not arise, then the user does not perceive the qualities of a system ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \notin nama \Rightarrow u? \mapsto s? \notin sukha$).

$$
\begin{array}{|l}
\hline
\textit{SUKHA} \\
\Delta \mathit{VEDANA} \\
u? : \mathit{USER} \\
s? : \mathit{SYSTEM} \\
\hline
u? \mapsto s? \in \mathit{nama} \\
u? \notin \operatorname{dom} \mathit{sukha} \\
u? \notin \operatorname{dom} \mathit{dukkha} \\
u? \notin \operatorname{dom} \mathit{uppekha} \\
\mathit{sukha}' = \mathit{sukha} \cup \{u? \mapsto s?\} \\
\hline
\end{array}
$$

4.2.5.2. *Dukkha.* *Dukkha* is a condition that occurs when the attitude toward a system is negative. *DUKKHA* is an operational schema that includes the state schema $\Delta VEDANA$. The operation schema *DUKKHA* updates the component *dukkha* in the schema *VEDANA*. The predicate $u? \mapsto s? \in nama$ in the lower part is a pre-condition; it defines conditions that a user must have perceived in a system quality when the *dukkha* operation arises as a state of mind. For example, a user's negative attitude toward a system arises only after the user perceives the qualities of a system ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u \mapsto s? \in dukkha \Rightarrow u \mapsto s? \in nama$). In the meantime, if the user's negative attitude toward a system does not arise, then the user does not perceive the qualities of a system ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \notin nama \Rightarrow u? \mapsto s? \notin dukkha$).

$$
\begin{array}{|l}
\hline
\textit{DUKKHA} \\
\Delta \mathit{VEDANA} \\
u? : \mathit{USER} \\
s? : \mathit{SYSTEM} \\
\hline
u? \mapsto s? \in \mathit{nama} \\
u? \notin \operatorname{dom} \mathit{sukha} \\
u? \notin \operatorname{dom} \mathit{dukkha} \\
u? \notin \operatorname{dom} \mathit{uppekha} \\
\mathit{dukkha}' = \mathit{dukkha} \cup \{u? \mapsto s?\} \\
\hline
\end{array}
$$

4.2.5.3. *Uppekha.* *Uppekha* is a condition of *vedana* that occurs when the attitude toward a system is neutral and cannot be expressed as positive or negative. *UPPEKHA* is an operational schema that includes the state schema $\Delta VEDANA$. The operation schema *UPPEKHA* updates the component *uppekha* in the schema *VEDANA*. The predicate $u? \mapsto s? \in nama$ in the lower part is a pre-condition; it defines conditions that a user must have perceived in a system quality when the *uppekha* operation arises as a state of mind. For example, a user's neutral attitude toward a system arises only after the user perceives the qualities of a system ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \in uppekha \Rightarrow u? \mapsto s? \in nama$). In the

meantime, if the user's neutral attitude toward a system does not arise, then the user does not perceive the qualities of a system ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \notin nama \Rightarrow u? \mapsto s? \notin uppekha$).

$$
\begin{array}{|l}
\hline
\textit{UPPEKHA} \\
\Delta VEDANA \\
u? : USER \\
s? : SYSTEM \\
\hline
u? \mapsto s? \in nama \\
u? \notin \operatorname{dom} sukha \\
u? \notin \operatorname{dom} dukkha \\
u? \notin \operatorname{dom} uppekha \\
uppekha' = uppekha \cup \{u? \mapsto s?\} \\
\hline
\end{array}
$$

4.2.6. Tanha.

> "Monks, craving for forms is inconstant, changeable, alterable. Craving for sounds... Craving for smells... Craving for tastes... Craving for tactile sensations... Craving for ideas is inconstant, changeable, alterable", Tanha Sutta [**35**].

Tanha (craving, desire) is a condition characterised by the intensified degree of attitudes toward a phenomenon. If there is no attitude toward a phenomenon, an intensified degree of attitude to a phenomenon will not arise. *Tanha* is categorised into *kama-tanha* (desire or craving for sensuality), *vibhava-tanha* (aversion or craving for non-being), and *bhava-tanha* (craving for neutral). A phenomenon is 'craved for sensuality' after *vedana* or an attitude toward a phenomenon has been positive. On ther other hand, a phenomenon is 'craved for non-being' after *vedana* or an attitude toward a phenomenon has been negative. In this case, *uppekha* is the only type of *vedana* that will not trigger *tanha* conditions. A user's intensified positive or negative attitudes toward a system will not arise if a user feels neutral toward a system ($\forall\, u? \mapsto s? \in vedana \bullet u? \mapsto s? \in uppekha \Rightarrow u? \mapsto s? \notin kamatanha \wedge u? \mapsto s? \notin vibhavatanha$).

Besides craving for sensuality and craving for non-being, craving for neutral is a condition that is always associated with other two previous types of tanha. This condition is also translated and understood as craving for 'not to decline' in Buddhism. It is a condition that a phenomenon is craved for maintaining proximity of its condition. In other words, it is a condition that does not accept anything worse than what has been craved. When a system is either craved for sensuality or craved for non-being of sensuality, it is always craved 'for not to decline'. Since *bhava-tanha* is always associated with *kama-tanha* and *vibhava-tanha*, it will not be formalised in the Dhammic framework. In this case, the *TANHA* is a state schema that includes the state schema $\Delta SANNA$. As *kama-tanha* and *vibhava-tanha* are

types of *tanha*, their functions are also defined in the same manner as the partial function *tanha* in the schema *SANNA*. The lower part indicates that all types of *tanha* are subsets equal to *tanha*.

$$
\begin{array}{|l}
\hline
\textit{TANHA} \\
\Delta SANNA \\
kamatanha : USER \nrightarrow SYSTEM \\
vibhavatanha : USER \nrightarrow SYSTEM \\
\hline
kamatanha \subseteq tanha \\
vibhavatanha \subseteq tanha \\
\hline
\end{array}
$$

4.2.6.1. *Kama-Tanha. Kama-tanha* is a type of *tanha* arising after *sukha* of *vedana*. It is a condition of an intensified degree of positive attitude toward a system in accordance with positive attitude. *KAMATANHA* is an operational schema that includes the state schema $\Delta TANHA$. The operation schema *KAMATANHA* updates the component *kamatanha* in the schema *TANHA*. The predicate $u? \mapsto s? \in sukha$ in the lower part is a pre-condition; it defines the condition that a user attitude toward using a system must have been positive before the *kama-tanha* operation arises in state of mind. For example, a user's intensified positive attitude toward a system arises only after the user's positive attitude toward a system ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \in kamatanha \Rightarrow u? \mapsto s? \in sukha$). In the meantime, if the user's positive attitude toward a system does not arise, then the user's intensified positive attitude toward a system will not arise ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \notin sukha \Rightarrow u? \mapsto s? \notin kamatanha$).

$$
\begin{array}{|l}
\hline
\textit{KAMATANHA} \\
\Delta TANHA \\
u? : USER \\
s? : SYSTEM \\
\hline
u? \mapsto s? \in sukha \\
u? \notin \operatorname{dom} kamatanha \\
kamatanha' = kamatanha \cup \{u? \mapsto s?\} \\
\hline
\end{array}
$$

4.2.6.2. *Vibhava-Tanha. Vibhava-tanha* is a condition of *tanha* arising after *dukkha*. It is a condition of an intensified degree of negative attitude toward a system. *VIBHAVATANHA* is an operational schema that includes the state schema $\Delta TANHA$. The operation schema *VIBHAVATANHA* updates the component *vibhavatanha* in the schema *TANHA*. The predicate $u? \mapsto s? \in dukkha$ in the lower part is a pre-condition; it defines the condition where a user's attitude toward using a system must be negative when aversion toward the system arises. For example, a user's intensified negative attitude toward a system arises only after the

user's initial negative attitude toward a system ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \in vibhavatanha \Rightarrow u? \mapsto s? \in dukkha$). In the meantime, if the user's negative attitude toward a system does not arise, then the user's intensified negative attitude toward a system will not arise ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \notin dukkha \Rightarrow u? \mapsto s? \notin vibhavatanha$).

VIBHAVATANHA

$\Delta TANHA$
$u? : USER$
$s? : SYSTEM$

$u? \mapsto s? \in dukkha$
$u? \notin \mathrm{dom}\, vibhavatanha$
$vibhavatanha' = vibhavatanha \cup \{u? \mapsto s?\}$

4.2.7. Upadana.

> "Just as if a great mass of fire of ten... twenty... thirty or forty cartloads of timber were burning, and into it a man would time & again throw dried grass, dried cow dung, & dried timber, so that the great mass of fire — thus nourished, thus sustained — would burn for a long, long time", Upadana Sutta [**36**].

Upadana (attachment, clinging) is a condition that occurs when a system is attached to and cognised by a human after the intensification of attitudes toward the system. In other words, an attached system is driven by an intensified degree of attitude. A system can be attached to for sensuality (or secure attachment in psychology) or for non-being (insecure attachment in psychology) [**46, 47, 215**]. A system, which is emotionally attached to for security or insecurity will influence the user's view of attachment to the system. If the user feels secure attachment to the system, the system will not be viewed by the user as offensive. In other words, the user will not get offended by the system if the user feels secure attachment to the system. In contrast, the user will get offended by the system if the user feels insecure attachment to the system.

Since a condition of attachment is preconditioned by different psychological conditions starting from perceived external properties, any change in external properties can result in influencing the entire chain of attached cognition. All suffering results from situations where the underlying states of mind of an attached phenomenon are triggered because a perceived phenomenon is not the same as an attached phenomenon.

The *UPADANA* is an operational schema that includes the state schema $\Delta SANNA$. The operation schema *UPADANA* updates the component *upadana* in the schema *SANNA*. The predicate $u? \mapsto s? \in tanha$ in the lower part is a pre-condition; it defines conditions, that external properties toward a system are perceived when the qualities of a system are perceived. For example, a user's attachment toward a system arises only after the user's

intensified attitude toward the system. A system is attached in accordance with craving for sensuality ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u \mapsto s? \in upadana \Rightarrow u \mapsto s? \in kamatanha$) or craving for non-being ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \notin upadana \Rightarrow u? \mapsto s? \in vibhavatanha$). If the user's intensified positive attitude toward a system does not arise, then the user's attachment toward a system for sensuality will not arise ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet \neg u? \mapsto s? \notin kamatanha \Rightarrow \neg u? \mapsto s? \in upadana$). In the meantime, if the user's intensified negative attitude toward a system does not arise, then the user's attachment toward a system for non-being will not arise ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet \neg u? \mapsto s? \notin vibhavatanha \Rightarrow \neg u? \mapsto s? \notin upadana$).

The predicate $upadana' = upadana \cup \{u? \mapsto s?\}$ is used to represent a condition when a user attaches to a system and $upadana' = upadana \setminus \{u? \mapsto s?\}$ to represent a condition when a user attaches to a system.

UPADANA

$\Delta SANNA$
$u? : USER$
$s? : SYSTEM$

$u? \mapsto s? \in tanha$
$u? \notin \operatorname{dom} upadana$
$u? \mapsto s? \in kamatanha \bullet$
$upadana' = upadana \cup \{u? \mapsto s?\}$
$u? \mapsto s? \notin vibhavatanha \bullet$
$upadana' = upadana \setminus \{u? \mapsto s?\}$

4.2.8. Cetana.

> "What one intends, what one arranges, and what one obsesses about...there is the production of renewed becoming in the future. When there is the production of renewed becoming in the future, there is future birth, aging and death, sorrow, lamentation, pain, distress, and despair. Such is the origination of this entire mass of suffering and stress" Cetana Sutta [**27**].

Cetana (intention) is an intention toward a phenomenon, which is situated in *bhava* (becoming) [**33**]. Cetana is the process of mind towards and becoming involved with a phenomenon. It is influenced by a condition of attachment. Cetana is a condition that forms a pattern in order to take action in accordance with a condition of attachment. The implication of *cetana* as bhava is also mentioned in cetana sutta [**27**] that: "What one intends, what one arranges, and what one obsesses about...When that consciousness lands and grows, there is the production of renewed becoming in the future". In systems engineering, *cetana* is an intention toward using or rejecting a system.

The *CETANA* is an operational schema that includes the state schema $\Delta SANNA$. The operation schema *CETANA* updates the component *cetana* in the schema *SANNA*. The predicate $u? \mapsto s? \in upadana \vee u? \mapsto s? \notin upadana$ in the lower part is a pre-condition; it defines that a condition of attachment must have already arisen when the *cetana* operation arises in one's state of mind. For example, a user's intention toward a system arises in response to the user's attachment toward a system, which can be adopting a system ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \in cetana \Rightarrow u? \mapsto s? \in upadana$) or rejecting a system ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \notin cetana \Rightarrow u? \mapsto s? \notin upadana$). If the user's attachment toward a system for sensuality does not arise, then the user's intention to adopt a system will not arise ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet \neg u? \mapsto s? \in upadana \Rightarrow \neg u? \mapsto s? \in cetana$). In the meantime, if the user's attachment toward a system for non-being does not arise, then the user's intention to reject a system will not arise ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet \neg u? \mapsto s? \notin upadana \Rightarrow \neg u? \mapsto s? \notin cetana$).

The predicate $cetana' = cetana \cup \{u? \mapsto s?\}$ is used to both represent a condition when a user intends to adopt a system and $cetana' = cetana \setminus \{u? \mapsto s?\}$ to represent a condition when a user intends to reject a system.

CETANA

$\Delta SANNA$
$u? : USER$
$s? : SYSTEM$

$u? \mapsto s? \in upadana \vee u? \mapsto s? \notin upadana$
$u? \notin \mathrm{dom}\, cetana$
$u? \mapsto s? \in upadana \bullet$
$cetana' = cetana \cup \{u? \mapsto s?\}$
$u? \mapsto s? \notin upadana \bullet$
$cetana' = cetana \setminus \{u? \mapsto s?\}$

4.2.9. Kamma.

> "What is the cause by which kamma comes into play? Contact is the cause by which kamma comes into play...[a]nd what is the result of kamma? The result of kamma is of three sorts, I tell you: that which arises right here & now, that which arises later [in this lifetime], and that which arises following that. This is called the result of kamma" [**39**].

Kamma (action) is an action toward a phenomenon. *Kamma* is classified into *jati* (birth, status of coming forth), which is pre-conditioned by *cetana* or intention. It is classified into *jati* because it is an action that what is intended comes forth. Despite being pre-conditioned by *cetana*, *kamma* and *cetana* are strongly connected, which is referred to intention and the result of intention that are inseparable [**33**]. In systems engineering, *kamma* is an action

toward using or rejecting a system. A system can be adopted or rejected by a user because of underlying intentions. A system will be adopted when a user's intention to use a system is strong. Conversely, a system will be rejected when a user's intention to reject a system strong.

The *KAMMA* is an operational schema that includes the state schema $\Delta SANNA$. The operation schema *KAMMA* updates the component *kamma* in the schema *SANNA*. The predicate $u? \mapsto s? \in cetana \lor u? \mapsto s? \notin cetana$ in the lower part is a pre-condition; it defines conditions where a user must have intention to adopt or reject a system when the *kamma* operation arises. For example, a user's action toward a system arises in response to the user's intention toward a system, which can be adopting a system ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \in cetana \Rightarrow u? \mapsto s? \in kamma$) or rejecting a system ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet u? \mapsto s? \notin cetana \Rightarrow u? \mapsto s? \notin kamma$). If the user's intention to adopt a system does not arise, then the user's action to adopt a system will not arise ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet \neg u? \mapsto s? \in cetana \Rightarrow \neg u? \mapsto s? \in kamma$). Also, if the user's intention to reject a system does not arise, then the user's action to reject a system will not arise ($\forall\, u : user, s : system \mid \exists\, u?, s? \bullet \neg u \mapsto s? \notin cetana \Rightarrow \neg u \mapsto s? \notin kamma$).

The predicate $kamma' = kamma \cup \{u? \mapsto s?\}$ is used to both represent a condition when a system is adopted by a user and $kamma' = kamma \setminus \{u? \mapsto s?\}$ to represent a condition when a system is rejected by a user.

KAMMA

$\Delta SANNA$
$u? : USER$
$s? : SYSTEM$

$u? \mapsto s? \in cetana \lor u? \mapsto s? \notin cetana$
$u? \notin \operatorname{dom} kamma$
$u? \mapsto s? \in cetana \bullet$
$kamma' = kamma \cup \{u? \mapsto s?\}$
$u? \mapsto s? \notin cetana \bullet$
$kamma' = kamma \setminus \{u? \mapsto s?\}$

4.3. Undesirable Symptoms of Upadana

Although there are different views in systems engineering, they share the same goal – that the system is finally adopted by the user after the user and the system are in contact ($\forall\, u \mapsto s \in phassa \mid \exists\, u?, s? \bullet u? \mapsto s? \in kamma$). At the same time, they also share the goal that the system will not be rejected by the user ($\forall\, u \mapsto s \in phassa \mid \neg \exists\, u?, s? \bullet u? \mapsto s? \notin kamma$). In most cases, systems engineers will design a system in such a way that the user will have positive attitude toward the system and adopt the system after the user and the system are in contact ($\forall\, u \mapsto s \in phassa \mid \exists\, u?, s? \bullet u? \mapsto s? \in sukha \Rightarrow u? \mapsto s? \in kamma$).

At the same time, they will also design a system in such a way that the user will not have a negative attitude toward the system and reject the system after the user and the system are in contact ($\forall\, u \mapsto s \in phassa \mid \neg \exists\, u?, s? \bullet u? \mapsto s? \in dukkha \Rightarrow u? \mapsto s? \notin kamma$).

However, a condition of attachment is also effective for users, since it is a condition that always underlies human intention and action toward a phenomenon. When a system is perceived by a user, the system is immediately cognised in each psychological condition. When the system is attached by the user and the user perceives the system again, there are two system states, including a recognised system (s) and a perceived system ($s?$). The most desirable condition of attachment for systems engineers is when the perceived system is attached for sensuality ($u \mapsto s? \in upadana$) and the cognised system is attached for non-being ($u \mapsto s \notin upadana$). For example, the user attaches to the new system proposed by systems engineers to replace the existing system that is no longer attached by the user. Replacing the existing with the new system does not offend the user. The user's defence mechanism to maintain proximity of the condition of attachment to the existing system can be avoided.

In constrast, the most undesirable condition of attachment is when the cognised system is attached for sensuality ($u \mapsto s \in upadana$) and the perceived system is attached for non-being ($u \mapsto s? \notin upadana$). For instance, the user attaches to the new system proposed by systems engineers as unwanted and offensive. The user's defence mechanism to maintain proximity of the condition of attachment to the existing system is intensified. It is the stage when the perceived system state is automatically attached in the user's mind as an undesirable feature of the cognised system. The user's mind is attached to the idea that rejecting the perceived system will sustain the cognised system ($\forall\, u \mapsto s \in upadana \mid \exists\, s? : system \bullet u \mapsto s? \notin kamma \Rightarrow u \mapsto s \in upadana$).

When the user has reached these symptoms of attachment, it is also the most undesirable condition for all systems engineers. The systems engineer needs to spend tremendous effort and time to make the user adopt the system. In many cases, the systems engineer's effort does not assure that the user will eventually adopt the system ($\forall\, u \mapsto s? \notin upadana \mid \exists\, s? : system \bullet u \mapsto s \in upadana \Rightarrow u \mapsto s? \notin kamma$). A number of cyclic attempts at addressing users' persistent attachment is an undesirable condition in systems engineering, because there is no guarantee how long the user's persistent attachment will remain. The system engineer may not be able to get the system project accepted by the user within a planned schedule and resources. The cyclic attempt to get the user accept the system is comparable to *samsara* in Buddhism, which can be defined as continuous movement, endless suffering, cyclic existence, perpetual wandering, transmigration, and wheel of suffering.

4.4. Conclusions

The Dhammic framework is a novel and original framework that represents psychological constructs from the perspective of Buddhist insights in a logical manner. The framework

explained that a system has no self before it is perceived and attached. Logical arguments were used to illustrate how a condition of attachment is derived and why and how this condition can contribute to systems failures. Since we live in a world of attachments, it is not surprising that a systems engineer wants to build a system based on his or her own closely held views. However, that is not desirable if it affects what the user has become attached to in a way that he or she has used the system already. These undesirable conditions of attachment are arguably internal mechanisms of mind underlying system project failures, including the case of SET failures discussed in chapter 3. In addition to attached views of SET developers underlying technological failures such as interoperability issues, e-commerce participants were reluctant to use SET because there were enforced to comply to SET security requirements. In other words, they were offended by SET security requirements proposed by SET developers, who were attached to their own security perspectives. In this case, systems engineering from a system engineer's point of view does not assure the realisation of successful systems. Instead, understanding conditions underlying behavioural intention to use a system can be valuable in systems engineering.

Part 2

Attachment, User Acceptance, and Experiments

CHAPTER 5

User Acceptance of Innovations

> "The importance of early measures in predicting usage behavior presents exciting opportunities to study many competing designs and choose the right design plan prior to significant investment of time and money. However, the stability of early measures should caution system designers, developers, and trainers that early pitfalls can have a lasting influence on user perceptions that are very difficult to change", Davis and Venkatest [**122**, p.44].

5.1. Introduction

In system acceptance theories, a number of models have been proposed to investigate and understand the factors affecting user acceptance and diffusion of innovations. This research aims at identifying constant constructs, factors determining an individual's decisions, satisfaction and intentions of individuals, and the use and adoption of innovations [**314**]. How a user actually responds to a system has been extensively measured, studied, and evaluated. Psychological conditions underlying human perceptions have been applied using different system acceptance theories. According to Davis and Venkatest [**122**], it is partially true from system engineer perspectives that a working prototype of a new system can reflect future usage behaviour because the prototype represents functionality toward user requirements. Dealing with user experiences such as perceived ease of use and perceived usefulness is also valuable in predicting user behavioural intention and actual usage [**119, 121**]. Among those theories, TAM (Technology Acceptance Model) is the most widely referred model that is constructed from psychological conditions of individuals in response to a system [**367**]. According to Chutter [**109**], TAM is the system acceptance model that has received the most attention in the information systems community. TAM is pointed out to be more appropriate than other integrated models that have less predictive power regarding the acceptance of innovations [**101**]. It is a useful theoretical model in explaining how a user interacts with a system. The relationship between psychological conditions is used to forecast the likelihood of innovations being accepted or rejected by users. This chapter reviews theories and approaches related to user acceptance of innovations that can be worth considering in systems engineering. It then discusses TAM in detail. While attachment is an influential condition to behavioural intention in Buddhism, This chapter investigates if the condition of attachment has ever been used in system acceptance theories.

5.2. Diffusion of Innovation

Rogers's [**291**] diffusion of innovation is a well established theory for user adoption of new ideas or things such as technology and information systems. The theory describes the innovation decision process, factors that determine the rate of adoption and the different types of adopters. In addition, the theory helps individuals predict the probability and rate of adopting a certain innovation. The four key components of the diffusion of innovations are time, communication channels, social system and innovation. Time affects the rate of adoption or the speed at which individuals adopt an innovation. The rate of adoption is given as the number of individuals who adopt an innovation during a certain time frame. During the innovation-decision process, an individual searches for information about the innovation in order to reduce uncertainty about its expected consequences. Communication is the process in which individuals create and share information with each other in order to reach a common understanding. While a channel is a critical component in passing a message from a source to a receiver, diffusion is a kind of communication with innovation, individuals or other units of adoption being the communication elements. Mass media communication channels are more efficient in creating awareness of innovations while interpersonal channels are more efficient in forming and altering individuals' attitudes towards a new idea. Rogers [**291**] argues that many individuals evaluate an innovation through subjective evaluation of close peers who adopted the innovation rather than basing their decisions on scientific research by experts. The social system is defined as a set of interrelated entities engaged in mutual problem solving to achieve a common objective. The members of the entities may be organizations, informal groups, individuals or subsystems. The social structure of any social system affects the diffusion of innovations because the process occurs in the confines of the social system. Moreover, Rogers [**291**] suggests that the attributes of the social systems influences members' innovativeness, which is the core criterion of classifying adopters. Innovation is the last key component defined as any initiative, practise or development recognized as new by individuals or existing units of adoption. An invention may be considered as new, even if it were invented long ago if certain individuals perceive it as new. In Rogers's theory, one significant obstacle to the adoption of innovations is uncertainty.

5.3. Theory of Reasoned Action (TRA)

TRA was developed in 1967 and revised later by Ajzen and Fishbein [**49, 148**]. In the 1980s, TRA was mainly used to study human behaviour. The main aims of the theory were to forecast and understand the motivational forces on actual behaviour and to comprehend any volitional behaviour. The theory excludes spontaneous, impulsive or habitual behaviours because such behaviour is not voluntary or the actor's conscious is not involved in the decision [**232**]. TRA also excludes behaviours entailing exceptional skills, exceptional resources or opportunities. A person may be prevented from doing certain behaviours due to lack of a skill, opportunity or cooperation from fellow actors and not due to a voluntary decision to refrain

from performing the behaviour. According to this theory, an individual's performance of a certain behaviour is determined by her/his behaviour intention (BI) to execute the behaviour. Moreover, BI is determined by an individual's influence and a normative influence. The individual influence is the attitude of the person (A) towards doing the behaviour while the normative influence is the subjective norm (SN). TRA can be expressed in its simplest form as a function:

$$BI = A + SN \tag{5.3.1}$$

Where BI represents a measure of an individual's intention to perform a particular behaviour. A represents a person's response or feeling about doing the target behaviour. Subjective norm (SN) is the person's perception that those significant to him/her think he/she ought or ought not to perform the action in question [**49, 148**]. TRA posits that an individual's feelings or attitudes towards behaviour are determined by the individual's salient beliefs (b_i) about outcomes of performing the action and evaluation (e_i) of those outcomes:

$$A = \sum b_i e_i \tag{5.3.2}$$

Beliefs (b_i) are described as a person's subjective likelihood that carrying out target behaviour will give rise to consequence i. The evaluation term (e_i) describes an implicit evaluative reaction to the outcome [**148**]. The function stands for an information-processing view of attitude development and transformation, which hypothesizes that external factors influence attitude only indirectly through alterations in the individual's belief structure. TRA posits that an individual's subjective norm (SN) is determined by a multiplicative function of the individual's motivation to comply (mc_i) and the individual's normative beliefs (nb_i):

$$SN = \sum nb_i mc_i \tag{5.3.3}$$

Motivation to comply is the actual or imaginary force one experiences for her/his behaviour to match the perceived expectations from other individuals. Normative belief is described as the perceived expectation of other particular referent persons regarding the volitional behaviour [**148**].

5.4. Theory of Planned Behaviour (TPB)

According to Ajzen [**48**], TPB, an extension of TRA, aims at predicting and explaining human behaviour in particular contexts like system acceptance. The fundamental factor in this theory is an individual's intention to execute a given behaviour. Intentions are assumed to capture the motivational aspects that influence actual behaviour. Where the intention to engage in actual behaviour is strong, there is a high likelihood of its performance. However, the performance of such behaviours depends on many non-motivational aspects like time,

skills or finances. These non-motivational factors show how much behaviour depends on people's control, necessary opportunities and availability or access to resources. Behavioural beliefs link actual behaviour and expected results. A behavioural belief is the subjective likelihood that the behaviour will produce a given result. Only a relatively small number of behavioural beliefs is readily accessible at any given time despite the fact that individuals may hold several behavioural beliefs in regard to any behaviour. As such, an individual's attitude towards the behaviour is determined by the accessible beliefs. Attitude is determined by the total number of accessible beliefs linking the behaviour to a variety of results and other features. In TPB, attitudes towards behaviour can help an individual determine the intention to behave in a specific manner. In summary, TPB posits that behaviour intention is revealed in the behaviour if an individual adopts or rejects the behaviour voluntarily. This highlights the perceived control an individual has about a desired behaviour. As a result, the behaviour becomes a product of affective and cognitive occurrences. The affective and cognitive occurrences succeed the conscious intention of performing behaviour. TRA and TPB only differ in the construct of planned behaviour [**314**].

5.5. Unified Theory of Acceptance and Use of Technology (UTAUT)

UTAUT was developed by Venkatesh et al. [**346**] to investigate and explain user intentions to utilize an IS (information system). Moreover, UTAUT aims at explaining the usage behaviour of an IS. UTAUT utilizes four main constructs: 1) social influence (the extent to which important referents (others) believe an individual should use technology); 2) facilitating conditions (the extent to which users believe that resources exist to sustain a technology or a system), performance expectancy (the extent to which a potential user believes that using a system helps in attaining his/her goals); and effort expectancy (the degree of simplicity/difficult in using a system or technology). These constructs are the factors that determine usage intention and behaviour. The constructs of the model are mediated by voluntariness, experience, gender and age of individuals. The UTAUT model is a unified theory as it was formulated from a review and integration of constructs from eight models of use and acceptance of technology. The review looked at the theory of reasoned action, technology acceptance model, theory of planned behaviour, the motivational model, combined theory of planned behaviour and technology acceptance model, PC utilization model, diffusion of innovation theory and social cognitive theory [**346**]. Different researchers have extended this model to include other constructs.

Perlusz [**279**] pointed out the importance of having emotions in the UTAUT model for understanding the complexity of psychological conditions between an individual and an innovation. Perlusz includes several emotional factors classified into positive and negative emotions in the UTAUT model. It was found that negative affect and positive affect had the same influence on technology acceptance. Although such emotional factors were not strong indicators, significant predictors of users' acceptance of innovations could be noticed when

subject experiences positive emotions. Moran [**269**] introduced anxiety and self-efficiency in the model because of their value in other competing models. Results of Moran's study show a significant correlation between attitude towards the use of technology and anxiety. In developing an E-Business Quality Model, Cody-Allen and Kishore [**111**] introduced e-quality, satisfaction and trust to the UTAUT model.

5.6. Technology Acceptance Model (TAM)

TAM based on TRA is a prominent theory of information systems, which was developed by Davis [**119, 120, 121, 123**]. TAM is a widely used model for predicting and explaining the usage of innovations. This model has become an influential research model in the field of Information Systems and used by many researchers and practitioners to identify or predict user acceptance of innovations. According to Teo [**337**, p.1], "researchers have sought to identify and understand the forces that shape users' acceptance so as to influence the design and implementation process in ways to avoid or minimize resistance or rejection when users interact with technology". Over the past decade, TAM has received substantial attention from many scholars and researchers [**105**]. A number of researchers have empirically tested the model and found out that psychological constructs used in the model yield statistically consistent results [**150**].

TAM posits that an individual's intention to use a system depends on two constructs, including the perceived usefulness and the perceived ease of use. According to Davis [**119**, p.320], perceived usefulness is "the degree to which a person believes that using a particular system would enhance his or her job performance". Perceived usefulness was introducted in TAM constructs as a metric for measuring the extent of a particular system's utility to an individual. In the meantime, the same author defined perceived ease of use as "the degree to which a person believes that using a particular system would be free from effort". Perceived ease of use was also introducted in TAM constructs as a metric for measuring the extent to which a particular system reduces effort used in performing a given task.

The first version of TAM assumed that users' attitude and the supposed usefulness of a system determine users' intention to use the system. The user's attitude was introduced as an essential construct for TAM in order to measure an individual's feelings to a particular system. Users' attitude towards a system can vary between two extreme degrees (e.g., good or bad, wise or foolish, unfavourable or favourable, beneficial or harmful, and positive or negative) [**120**], depending on the perceived usefulness and the perceived ease of use. In the meantime, the perceived usefulness can be affected by the perceived ease of use.

5.6.1. TAM Limitations. Despite being the most popular system acceptance model, TAM has received a number of criticisms. TAM has various limitations, which include its failure to identify obstacles that hamper technology acceptance and adoption. According to Turner et al. [**344**], although TAM conditions proceed from the perceived ease of use and perceived usefulness to actual use of a system, TAM is usually validated by measuring

behavioural intention to use rather than actual usage. In addition, TAM does not provide adequate guidance concerning how user system acceptance can be influenced through design perspective. However, TAM has been validated through a number of empirical experiments to represent validity of predictive reliability and conditions underlying user acceptance of a system [**362**].

Moreover, the ease of application of TAM has resulted into its over-use at the expense of developing other models [**331**]. Yang and Yoo [**366**] criticise that only affective attitudes have been emphasised in TAM as attitudes towards using while attitudes in psychology can be classified into affective attitudes and cognitive attitudes. In Yang and Yoo's experiments [**366**], question items were constructed to cover both affective and cognitive attitudes. These authors conclude that attitude deserves more attention in the literature. While the purpose of TAM is to predict user acceptance of innovations from psychological constructs measured using Likert scales, the TAM scales were criticised for not having an open-ended text field in which users could describe the purpose of their usage of innovations [**296**].

5.6.2. TAM Extensions. TAM has been extended from time to time. Although TAM is effective in predicting and explaining user acceptance of health IT, there is much room for improvement [**188**]. Many scholars and researchers have extended TAM due to its simplicity. A number of researchers have attempted to extend this model by introducing constructs from related models, by introducing extra or substitute belief factors, and by examining mediators of perceived convenience and perceived ease of use [**362**]. A number of extensions proposed to strengthen predictive ability of TAM are classified into three approaches [**362**]: 1) factors from related models are introduced to TAM; 2) factors related to psychological conditions are introducted to TAM; and 3) external variables influencing 'perceived ease of use' and 'perceived usefulness' are introducted to TAM.

In Teo [**333, 334**], the external factor of gender was used to illustrate that the influence of perceived usefulness on attitude towards using a system was greater for females than males. TAM was also used to explore the IT acceptance by university lecturers at an applied science private university [**51**]. Perceived complexity was proposed as another influential factor in the exploration. The results show that there is no significant correlation between perceived usefulness and the actual use. However, there is are significant correlations from perceived ease of use and perceived complexity to the actual use. In Mahinda and Whitworth [**252**], Web of System Performance (WOSP) criteria such as security, connectivity, flexibility, extendibility, privacy, and reliability were proposed for TAM extensions. In Kuo and Yen [**230**], perceived innovativeness and perceived cost were proposed to collaborate with TAM in order to investigate the behavioral intention to use 3G mobile value-added services. Two proposed factors were used to construct hypotheses if there are direct correlations between perceived innovativeness and perceived ease of use and perceived cost and attitude toward using. Dishaw and Strong [**130**] incorporate Task-technology Fit with TAM.

Agarwal and Prassad [**45**] added the variable of compatibility in the original technology acceptance model. Some scholars like Agarwal and Karahanna [**44**] added the construct of playfulness, self-efficacy and cognitive absorption in their research. Notably, Chau and Hu [**100**] added the construct of peer influence to the TAM model. Chiu, Lin and Tang [**107**] added the construct of personal innovativeness in the original technology acceptance model while Chen (2005) added trust construct to the technology acceptance model. TAM has been applied in different sectors of information systems and information technology. Moon and Kin (2001) extended TAM to expound on consumers' acceptance of the World Wide Web. Lin, Shih and Sher [**243**] extended TAM to clarify and explain behavioural intentions of e-stock users in utilizing and adopting technology.

The major advantages of TAM are that it avails psychological constructs and factors that result into system acceptance and adoption. In addition, TAM can be explained and extended easily unlike other models such as TRA, TPB and diffusion of innovation. Chen et al. [**105**], argue that TRA and TAM differ in two aspects. First, TAM brings in two new constructs; perceived ease of use and perceived usefulness. In TAM, the two constructs can predict a person's attitude or feeling towards the use of a system or application. Secondly, TAM excludes subjective norms as a factor that determines intention. Moreover, TAM has been used mainly to predict the embracing, adoption and use of IT. TAM is more economical and robust in different IT applications [**105**].

5.7. TAM with A Condition of Attachment

In addition to TAM's psychological constructs, some researchers have proposed emotional attachment as an essential condition that may influence behavioural usage of innovations. They hypothesise that this condition can be worthy of consideration as a construct that strengthens TAM predictability. This section reviews those researches on TAM with a condition of attachment.

5.7.1. Maholtra and Galletta. According to Maholtra and Galletta [**253**, p.5], psychological attachment is defined as "the degree of commitment of the IS user toward system use based on the effect of social influences on his or her behaviour". The psychological attachment used in Maholtra and Galletta [**253**] is based on Kelman's [**221**] work on processes of social influence, including compliance, identification and internalization. In Kelman [**221**], social influences affect users in their internalization, compliance and identification of a particular induced behaviour. Maholtra and Galletta [**253**] conducted research extending TAM by incorporating social influence on user's attitudes and intentions towards using IT. Maholtra and Galletta [**253**] observed that many researches on TAM did not account for social influence in the utilization and adoption of new information systems or IT. The psychological attachment construct is used in these authors' research because it may highlight how social influences shape users' commitment to the use of an innovation.

In Maholtra and Galletta [**253**], questionnaires were used to collect data. The questionnaires had scales which were used to measure the constructs contained in the research model, including behavioural intentions, attitude, actual use and perceived use and perceived ease of use constructs. The analysis of data collected provided ample evidence to check the reliability of and validate the construct of social influence, measures used and the model adopted in the study. The following hypotheses were used in their research: a) There would be a positive relationship between behavioural intentions and compliance b) The relationship between behavioural intentions and internalization would be positive c) Identification and behavioural intentions construct would have a positive relationship d) Compliance and attitude towards using a system would have a positive relationship e) The relationship between attitude towards using a system and internalization would be positive f) Attitude towards using a system and identification would be related positively. Multiple linear regression equations were used to test the hypothesized relationships above. The study analysed 208 reliable responses gathered from the respondents.

In their study, the researchers concluded that emotional attachment plays a significant role in influencing users' towards using a particular information system. With regard to the influence on attitude of users', Maholtra and Galletta [**253**] found out that compliance has a negative influence on attitude of users while identification and internalization have a significant positive influence on attitude. In this case, the researchers suggested that the identification factor and the perceived ease of use component are the most significant predictors of attitude. However, compliance and perceived use components play a relatively minor role in explanation and prediction of users' attitudes toward an information system. As such, Maholtra and Galletta [**253**] rejected hypothesis (d) and confirmed hypothesis (e) and (f). The research suggests that there is a positive relationship between perceived use and perceived ease of use components on attitude, as suggested in the original TAM. Moreover, the researchers observed that internalization and identification components had significant positive relationships with attitude. However, the compliance component had a weaker negative relationship with the attitude component. With regard to influence on the behaviour intention of users, the researchers confirmed the positive relationship between perceived use and attitude components as suggested in the original TAM model. Consequently, they rejected hypothesis (a), (b) and (c) above. In regard to influence on IS use, Maholtra and Galletta [**253**], suggested that there was a positive relationship between IS use and behaviour intentions.

In conclusion, it is observed that where social influences create a feeling of compliance, they negatively influence users' attitudes towards using and adopting an information system. Conversely, where they generate a feeling of identification and internalization on the user, the positively influence the users' attitude on using and adopting an IS. The findings also suggest internalization by the users play an important role, than perceived use, in shaping usage

behaviour and acceptance. Thus, social influence plays a pertinent role in users' commitment towards use of an innovation.

5.7.2. Read, Robertson and McQuilken. Read, Robertson and McQuilken [**288**] conducted a study on TAM with a condition of emotional attachment. The researchers used an extended version of TAM with emotional attachment (TAME) with respect to consumers adopting e-readers for pleasure reading. These authors assume that e-readers are supposed to offer a better reading experience than paper books. Notably, users' are bound to consider some factors before adopting e-readers for pleasure reading. Users may consider the ease in transporting the e-reader, ease of access to content and reading, and comfort level of using an e-reader. Read et al. [**288**] criticise the original TAM model for not having users' emotions in the structure on adopting technology. In this case, the scholars extended the original TAM model by incorporating emotional attachment to the attitude construct in the original model. The emotional attachment has various components which include affection, connection and passion. This extension aims at focusing on present-today users' emotions as opposed to affective reactions to future events. Particularly, the extension also focuses on integrating emotions in use of TAM in a consumer environment.

Read et al. [**288**] argue that some users are emotionally attached to paper books. These authors hypothesised that this emotional attachment can be an obstacle to consumers' adoption of e-reader technology. According to Read et al. [**288**], users who are devoted to a product or brand are unwilling to make sacrifices for other products. Read et al. [**288**] opine that users are tied to their paper books to an extent that they treat them like shrines. This is due to the fact that some sensory feelings like the feel of paper books can elicit significant emotions in users. The features of paper books (appearance, markings or creases) can also elicit joy in users. In this case, the physical qualities of paper books mean more to their owners than the content written in them. This shows how emotional attachment grows over time thereby leading to the development of meaning [**341**]. As such, it may be difficult for individuals to adopt e-readers at the expense of paper books.

In the context of their research, such commitment may be reflected in users' foregoing the benefits of using an e-reader by maintaining their relationship with paper books. Users who are devoted/emotionally attached to paper books are prone to have negative attitudes towards using and adopting e-readers for pleasure reading.

The following hypotheses were used for the TAME experiment [**288**]:

- H1) There is a positive relationship between users' attitude and perceived ease of use of e-reader technology
- H2) The relationship between users' perceived use and perceived ease of use of e-readers for pleasure reading is positive
- H3) Users' perceived usefulness and attitude towards use of e-readers for pleasure reading is positive

- H4) There is a positive relationship between consumers' perceived use and behavioural intentions to adopt e-reader technology
- H5) Users' attitude and their behavioural intentions to adopt and use e-reader technology is positively related
- H6) There is a negative relationship between users' emotional attachment to paper books and their attitude towards adopting e-readers for pleasure reading Read et al. (2011) utilized a combination of different methods and phase-design in their study.

The first phase of the research utilised in-depth interviews to collect data. The researchers interviewed six respondents who were well recruited. The aim of the interviews was to determine the level of users' emotional attachment to paper books. The second phase of the study entailed a pre-test of the main questionnaire. At this stage, marketing experts were required to fill the questionnaires and identify any problems for correction by the researchers. The third phase of data collection entailed a questionnaire survey of online e-reader users. The respondents filled out a questionnaire via an online link. For purposes of clarity, the researchers used 5 items to measure PU, a three-dimensional measure of emotional attachment, 4 items to measure users' attitudes, and 4 items to measure behavioural intentions of users to adopt e-reader technology.

The questionnaire survey attracted 500 respondents. Read et al. [**288**] found out that some users were emotionally attached to paper books. However, the users were attached to the paper books because of the format and not content. In testing their hypotheses on TAME, the researchers found out that the relationship between users' attitude and their emotional attachment was weak and negatively related. This confirmed hypothesis (H6) of the study. Read et al. [**288**] noted that the findings were like that because adoption of e-readers does not prevent the users from collecting and reading paper books. Particularly, the findings of the study confirmed all hypotheses advanced by the scholars. This means that the study supported the original model of TAM.

The researchers point out that the strongest relationship in their study was between users' perceived use and their perceived ease of use of e-readers for pleasure reading. Ease of use and perceived usefulness were also related with users' attitudes towards adopting e-reader technology. There was a direct relationship between users' behavioural intentions to adopt e-readers and perceived usefulness. In regard to ease of use, its impacts on users' behavioural intentions were mediated by their attitudes towards using e-reader technology.

5.8. Conclusions

Theories and frameworks related to user acceptance of innovations have been reviewed. Among these theories, TAM is the most widely used framework that represents psychological constructs underlying human behaviours in technology adoption. A number of research scholars have extended TAM by introducing external and internal factors that may strengthen predictive ability of TAM. While proposed external factors were aimed to measure how they

influence users' perceived ease of use and perceived usefulness, internal factors were proposed to measure how they are correlated with users' intention to use and actual usage.

The condition of attachment has been proposed to extend TAM in different applications. This condition is located in different positions in accordance with the researchers' hypotheses. The condition of attachment was added in the TAM structure in order to measure if there is a strong correlation between attachment and perceived ease of use or perceived usefulness. However, TAM researchers extending the condition of attachment did not pay much attention to the condition of proximity maintenance although the condition of proximity maintenance was pointed out by Bowlby [**85, 86**] as a characteristic of attachment. Despite being studied and experimented in psychology, furthermore, the condition of attachment has not yet been emphasised as a critical condition underlying all problems. In systems engineering, systems engineers have not noticed the significance of attachment as a cause of system failure.

In Buddhism, on the other hand, the condition of attachment have been acknowledged as the origin of suffering for millennia. According to Ordinarymind.Com [**1**], attachment in Western psychology is related to the ability to form intimate, loving relationships whilst Buddhism has nothing against the positive qualities of attachment in the western sense. Instead, the word attachment in Buddhism refers to when one attempts to control inner or outer environment that eventually leads to suffering. Attachment in the root cause of all sufferings and is central to human behaviour because the condition of certainty maintenance. An individual usually attempts to maintain the condition of an attached phenomenon with or without his/her consciousness, while the reality of all phenomena is uncertain. As such, all individuals suffer from birth, aging, sickness, and death, which are four inevitable facts of any phenomenon.

These four inevitable facts from Buddhist insights are also applicable in systems engineering. Individuals, who attach to a particular condition of a system, may be offended and become emotional if the attached system is updated, outdated, misfunctioned, and terminated, which are comparable to birth, aging, sickness, and death in Buddhism respectively. When these individuals are offended, their behavioural intentions and actions are usually triggered because of the condition of certainty maintenance associated with the attached system. As a consequence, the condition of attachment in Buddhism is considered as a promising TAM extension for predicting technology acceptance and adoption, since this condition is related with particular behaviours like certainty maintenance and willingness to defend an attached object. While TAM posits that attitudes towards using influences behavioural intention, the position of attachment located between attitudes and intention in the Dhammic framework can be useful as an extension to the TAM structure.

CHAPTER 6

DTAM (Dhammic TAM)

6.1. Introduction

This chapter proposes Dhammic TAM (DTAM), which is based on TAM extended by the condition of attachment in Buddhism. Some psychological measurements were conducted in accordance with Buddhist states of mind in order to find out whether the condition of attachment from Buddhist insights plays a significant role in technology acceptance and adoption and could substantially enhance the predictability of TAM. If the result shows that the condition of attachment has a stronger influence on behavioural intention to use than attitude toward using, it can be summarised that a condition of attachment plays an important role in how the user adopts the system and should significantly enhance the predictability of TAM. Such a result would confirm the validity of Buddhist insights that the condition of attachment is central to human behaviour. Conversely, it can also be concluded that the condition of attachment may not be necessary as an extention to TAM if the results show that the condition of attachment does not have a stronger influence on behavioural intention to use than attitude toward using. Although such a result may not prove the usefulness of Buddhist insights in systems engineering, the results would still confirm the validity of TAM. In the DTAM experiment, the condition of attachment follows the notion of Buddhist attachment situated between intensified degree of attitude and intention. It is positioned between users' attitude towards using and behavioural intention.

In order to measure the condition of attachment, a particular technology was used as an instrument to investigate the condition of attachment. Facebook, launched in February 2004 and invented by Mark Zuckerberg and his colleagues at Harvard University, was used to investigate the condition of attachment of participants. It is the most popular social networking site and it has become one of the most widely used communication channels all over the world. According to demographics on Facebook conducted by checkfacebook[1] on March 6, 2013, Thailand is the 15th largest country on Facebook with 18,202,320 users from the total of 963,812,360 users. Facebook has become part of the communication culture. People can use Facebook for a number of reasons. In Khalid et al. [**224**, p.49], "Facebook is stage, like fashions, where people share information, ideas, personal feelings, current affairs, upload their information, group discussions and many more that sort of thing" [sic]. Furthermore, the use of Facebook has migrated to the smartphone, which is an innovation of the mobile phone integrating with PDA (Personal Digital Assistant), which has become widely used all

[1]Checkfacebook, http://www.checkfacebook.com

over the world. According to the statistics on Facebook mobile users in January 2013 [**113**], there are 192 million users on Android and 147 million users on iPhone. There are other Facebook mobile users on other operating systems and mobile applications.

Although TAM is generally used to predict user acceptance of a new system, experimenting on an existing system that has been used by users can be sufficient to investigate the condition of attachment as correlations associated with TAM constructs may not be significantly varied between a new system and a used system. As supported by Davis and Venkatest [**122**, p.43], "The findings revealed that behavioral intention and perceived usefulness measured before hands-on experience with a software product were highly correlated with, and not significantly different from the same measures taken after one month and three months of hands-on experience with the system". Recently, there have been several TAM applications to study conditions associated with how users accept and use Facebook [**102, 224, 236, 271**] and the results still confirm the validity of TAM constructs. Based on a consider number of TAM empirical measurement results and the notion of attachment in Buddhism, the following hypotheses were advanced.

H1:: There is a positive relationship between users' perceived ease of use and their perceived usefulness of Facebook.

H2:: There is a positive relationship between users' perceived usefulness and their attitude toward using Facebook.

H3:: There is a positive relationship between users' perceived ease of use and their attitude toward using Facebook.

H4:: There is a positive relationship between users' perceived usefulness and their attachment toward using Facebook.

H5:: There is a positive relationship between users' attitude toward using and their attachment toward using Facebook.

H6:: There is a positive relationship between users' attitude toward using and their behavioral intention of using Facebook.

H7:: There is a positive relationship between users' perceived usefulness and their behavioral intention of using Facebook.

H8:: There is a positive relationship between users' attachment toward using and their behavioral intention of using Facebook.

H9:: There is a positive relationship between users' attachment toward using and their actual use of Facebook.

H10:: There is a positive relationship between users' attitude toward using and their actual use of Facebook.

H11:: There is a positive relationship between users' perceived ease of use and their actual use of Facebook.

H12:: There is a positive relationship between users' perceived usefulness and their actual use of Facebook.

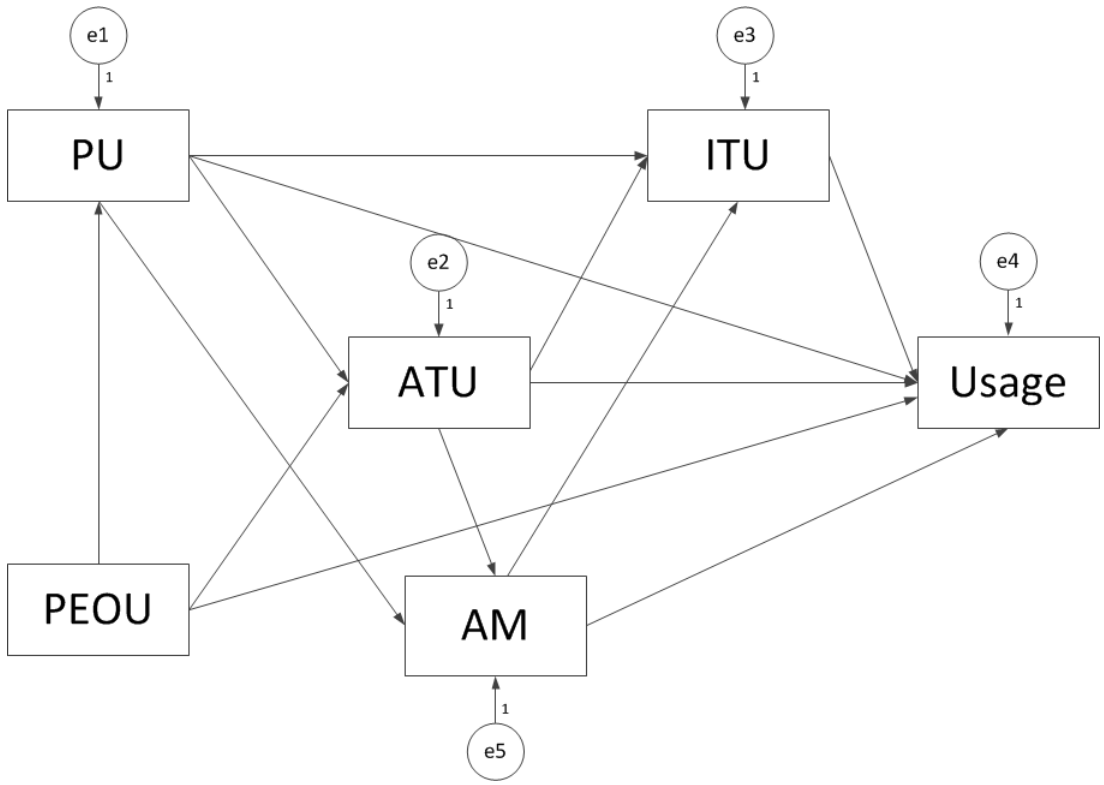

FIGURE 6.1.1. Hypothesised Model (or DTAM)

H13:: There is a positive relationship between users' behavioral intention of using Facebook and their actual use of Facebook.

6.2. Methodology

This section describes the methodology of the study, including instruments, participants, measurements, and procedures.

6.2.1. Instrument Development. A questionnaire is a quantitative data collection method that has been widely used in TAM. It is used to investigate the correlations in numerical terms consisting of a number of questions that the participant has to answer in a set format [**323**]. This research involved the use of an online questionnaire, since it has been acknowledged as an effective and economical tool for collecting data collection [**87**]. Participants were asked to answer different sets of questions about their perceptions of Facebook in accordance with TAM constructs with the condition of attachment included (e.g., perceived ease of use, perceived usefulness, attitude toward using, attachment toward using, and behavioural intention toward using.).

In order to establish the construct validity of the content, questions were generated from validated instruments, such as those used in previous TAM research and modified to fit the Facebook context. In addition, the questionnaire followed criteria for questionnaire design [**87, 88, 164**] to ensure the quality of the questionnaire. For example, all question items were

grouped in accordance with the TAM structure in order for participants to follow logically from one question to the other. Technical words were avoided for questions to be clear and understandable for the participants. A pilot of the questionnaire was tested with colleagues and students.

The experiment was conducted in Thailand, the English version of the questionnaire (Appendix A) was translated into Thai (Appendix B). When one language is translated to another, however, it may have a direct impact on the validity of the use and meaning of words. In order to validate the compatibility of the questionnaire, the author consulted with other bilingual people from the same university about the use and meaning of words identified as problematic. This procedure is suggested in the literature [**93, 359**]. Where there were mismatches between the translations, the translators cooperated until a consensus was reached. Before implementing the survey, the instrument was reviewed by academics and practitioners knowledgeable of survey design. Particularly, a prominent figure with extensive experiences in TAM experiments was also consulted about question items used in the experiment. Modifications of the survey were made in accordance with the suggestions given.

6.2.2. Participants. According to Khalid et al. [**224**, p.49] , "Students are the main user of facebook but they normally use it for fun and pleasure". In order to test the hypotheses, participants in this study were students from Phuket Rajabhat University (PKRU), who were capable of getting access to Facebook. Recruitment of participants occurred via advertising posters in both English (Appendix C) and Thai (Appendix D) versions on the university's bulletin boards, which were located inside and outside of the computer labs of each department and the ICT centre of the university. The PKRU's Vice-Chancellor was formally requested to approve the recruitment of participants and the request was approved on March 25, 2013 (Appendix E and F). The participants were informed that no compensation would be given to them and that the experiment was voluntary (Appendix G). In order to guarantee robust structural equation modelling, a minimum sample size of 200 is recommended by Harris and Schaubroeck [**177**]. This number is also consistent with guidelines established by MacCallum, Browne, and Sugawara [**250**], who proposed that more than 195 participants are required in order to reach a power level of at least 0.80 for tests of close fit, not-close fit, and exact fit. However, there were 500 participants in the DTAM measurement. In order to ensure that there was no coercion for the validity of the study, direct contact between the author and participants was avoided.

6.2.3. Measurement. The questionnaire contains different questions for measuring participants' actual usage of Facebook. It is also consisted of question items for measuring partipants' perceptions in accordance with TAM. Although the main hypothesis is to measure whether a condition of attachment has a direct influence on behavioral intention, there are other relevant conditions in TAM that must also be measured. A Likert scale [**242**], a popular

instrument to measure human perceptions in TAM, was used in the questionnaire. A seven-point Likert scale from 1 (strongly disagree) to 7 (strongly agree) was used to measure all question items on TAM factors with the condition of attachment included. In order to ensure the internal consistency of question items, most TAM research depend heavily on Cronbach's alpha developed by Lee Cronbach in 1951 [**115**]. The Cronbach's alpha is the most widely used objective measurement of reliability that has been applied in various disciplines such as social sciences, business, and medical sciences. It is used to measure the internal consistency of a scale, which is expressed as a number between 0 and 1 [**330**]. The evaluation criteria of Cronbach's alpha coefficients are varied from $\alpha < 0.5$ (unacceptable) to $\alpha \geq 0.9$ (excellent).

While TAM consists of several psychological variables, there have been several statistical techniques for analysing the relationship between independent and dependent variables in TAM. For instance, the linear correlation or Pearson's correlation coefficient was used to measure the strength of the linear relation between two quantitative variables ($-1 \leq r \leq 1$) where r indicates the strength of relationship. The strength of positive association between the two variables is evidenced if r is closer to 1. In constrast, the strength of negative association between the two variables is evidenced if r is closer to -1. If r is close to 0, it is evidence that there is no positive or negative association between the two variables. Multiple regression analysis [**327**], a statistical technique for estimating the causal relationships between a dependent variable and independent variables, was also used in addition to or in comparison to Pearson's correlation.

However, the measurement of psychological constructs in DTAM is based on SEM (Structural Equation Modelling), which is a comprehensive statistical approach for testing relations among hypothesised (observed and latent) variables [**195, 196, 227**]. According to Hox [**192**, p.1], "the structural equation model implies a structure for the covariances between the observed variables, which provides the alternative name *covariance structure modeling*". This approach is also widely used in the behavioural sciences, including psychometric design and measurements [**192**]. In Teo and Khine [**338**], "SEM is commonly known as causal modeling, or path analysis, which hypothesizes causal relationships among variables and tests the causal models with a linear equation system". There are a number of experiments on causal relationships using SEM in various disciplines [**332, 335, 336, 338**]

In this thesis, the thesis hypotheses are represented in a causal model that allows the relationships (paths) between psychological constructs in the model to be tested. Then, the model is tested against the data collected from participants in order to evaluate how well the model fits the data (fit indices). Path coefficients, standardised versions of linear regression weights, are represented by SEM to examine the causal influence among hypothesised constructs in DTAM. The results of path coefficients are divided into an unstandardised coefficient (B) and a standardised coefficient (β).

In SEM, the CR (Critical Ratio), which is a T-test with a null hypothesis that the path does not exist, is used to test the relationships. The CR is used to confirm whether causal

Items	Descriptions
PEOU1	Using Facebook is easy for me.
PEOU2	I find it easy to use Facebook to connect with friends.
PEOU3	It is easy for me to become skillful at using Facebook to connect with friends.
PEOU4	Using Facebook is a flexible way for me to interact with my friends.
PEOU5	My interaction with Facebook for connecting with friends is clear and understandable.

TABLE 1. Five items for measuring perceived the ease of use of Facebook.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.893	.897	5

FIGURE 6.2.1. PEOU Reliability Statistics

relationships between two constructs actually exist. The null hypothesis is accepted and the path is rejected when the CR value is less than 1.960. On the other hand, the null hypothesis is rejected and the path is accepted when $CR \geqq 1.960$, which means there exists the statistical significance of the path coefficient at ($p < 0.05$). If $CR > 2.576$, there is the statistical significance of the path coefficient at ($p < 0.01$). When $CR > 3.291$, there is the statistical significance of the path coefficient at ($p < 0.001$), which is represented in the table as ***.

Perceived Ease of Use (PEOU). Perceived Ease of Use (PEOU) is defined as "the degree to which a person believes that using a particular system would be free from effort" [**119, 121**]. The scales used to measure PEOU were adapted from the highly reliable perceived ease of use scale, with an excellent rate of Cronbach alpha coefficients ($\alpha = .91$), developed by Davis, Bagozzi, and Warshaw [**120, 121**]. PEOU in this context is similar to *nama*, a perceived quality in Buddhism, which is conditioned by *rupa*, a perceived external property of a system. Table 1 shows five modified questions for measuring the PEOU of Facebook.

Based on the results reported in Figure 6.2.1, the overall reliability is very high and indicates a strong internal consistency among the five question items for measuring perceived ease of use of Facebook ($\alpha = .893$). This implies that these question items are reliably measuring the same construct. This also confirms the reliability of question items for measuring perceived ease of use suggested by Davis [**119**].

The Corrected Item-Total Correlations represented in Figure 6.2.2 displays the correlations between a particular question item and the sum score of the other four items. de Vaus [**124**, p.184] suggested that $r < .30$ is considered as a weak correlation for item-analysis purposes and should not be used to form a composite score for the variable in question. However, the correlation between PEOU1 and the sum of PEOU2 to PEOU5 is $r = .752$.

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
PEOU1	22.98	11.253	.752	.601	.866
PEOU2	22.95	11.218	.786	.656	.860
PEOU3	23.17	10.716	.795	.645	.856
PEOU4	23.07	11.360	.739	.555	.869
PEOU5	23.44	10.819	.643	.423	.896

FIGURE 6.2.2. PEOU Item-Total Statistics

This means that there is a strong and positive correlation between the scores on the one item (PEOU1) and the combined score of the other four (PEOU2 to PEOU5). This strong and positive correlation is also applicable to other question items such as PEOU2, PEOU3, PEOU4, and PEOU5, where $r = .786, .795, .739, .643$ respectively. This can be used to assess how well one item's score is internally consistent with composite scores from all other remaining items. A column containing the 'Cronbach's Alpha if item Deleted' in the same figure displays the Cronbach's alpha that would result if a given item was deleted. The value presented in this column represents the alpha value if the given item was not included. For example, the Cronbach's alpha, if PEOU1 was deleted, would decline from the overall total of .893 to .866. Since almost all of the question items excepting PEOU5 would decline with the removal of them, they appear to be useful and contribute to the overall reliability of PEOU. Although Cronbach's alpha would increase from .893 to .896 if PEOU5 were deleted, all five question items should be retained because the alpha does not significantly increase from deleting PEOU5. In addition, PEOU5 still correlates well with the composite score of other question items (the item-total correlation for PEOU5 is .643). As such, there is no statistical reason to remove PEOU5.

Perceived Usefulness (PU). Perceived Usefulness (PU) is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" [**119, 121**]. Six questions were adapted from the highly reliable perceived usefulness, with an excellent rate of Cronbach alpha coefficients ($\alpha = .97$), developed by Davis, Bagozzi, and Warshaw [**120, 121**]. Similar to PEOU, PU in this context is comparable to *nama*, a perceived quality in Buddhism, which is conditioned by *rupa*, a perceived external property of a system. In Buddhism, perceived qualities are not distinguished, but treated as *nama*. Table 2 represents six modified questions for measuring PU of Facebook.

Figure 6.2.3 shows that the overall reliability is very high, indicating strong internal consistency, among the six question items for measuring perceived usefulness of Facebook ($\alpha = .932$). This indicates that these question items are reliably measuring the same construct, which confirms the reliability of the question items for measuring perceived usefulness suggested by Davis [**119**].

Items	Descriptions
PU1	Using Facebook enables me to connect with friends more quickly.
PU2	Using Facebook improves my performance in connecting with friends.
PU3	Using Facebook improves my productivity in connecting with friends.
PU4	Using Facebook enhances my effectiveness in connecting with friends.
PU5	Using Facebook makes it easier to connect with friends.
PU6	Overall, I find using Facebook useful in connecting with friends.

TABLE 2. Six items for measuring perceived usefulness of Facebook.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.932	.933	6

FIGURE 6.2.3. PU Reliability Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
PU1	27.48	20.978	.734	.548	.929
PU2	27.79	20.487	.812	.696	.918
PU3	27.44	20.851	.822	.691	.917
PU4	27.61	20.572	.857	.761	.912
PU5	27.42	21.250	.830	.699	.916
PU6	27.40	22.144	.763	.607	.925

FIGURE 6.2.4. PU Item-Total Statistics

In Figure 6.2.4, there is a strong and positive correlation between the scores on the one item and the combined score of the other items ($r > .7$ for PU1 and PU6, and $r > .8$ for PU2, PU3, PU4, and PU5). Please note that the Cronbach's alpha would drop from the overall total of .932 if any question item were deleted. Since Cronbach's alpha would decline with the removal of any one of the items, they all appear to be useful and contribute to the overall reliability of PU. Therefore, there is no statistical reason to remove any of these question items.

Attitude Toward Using (ATU). ATU was proposed in [**120**] as another psychological element that influences actual system use. Five questions were developed from the highly reliable attitude toward using, with excellent rate of Cronbach alpha coefficients ($\alpha = .96$), adapted from Ajzen and Fishbein [**49**] in Davis, Bagozzi, and Warshaw [**120**]. Attitude refers to the extent an individual has an unfavourable or favourable assessment or appraisal of a material object [**48**]. In Buddhism, ATU is comparable to vedana, which is classified into

Items	Descriptions
ATU1	Using Facebook is a good idea.
ATU2	Using Facebook is a wise idea.
ATU3	Using Facebook is favourable.
ATU4	Using Facebook is beneficial.
ATU5	I feel positive to use Facebook.

TABLE 3. Five items for measuring attitudes towards using Facebook.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.899	.900	5

FIGURE 6.2.5. ATU Reliability Statistics

three types of attitude towards a phenomenon, including positive, negative, and neutral. However, ATU further covers tanha, which is an intensified degree of attitude. Since an intensified degree of attitude is an extreme degree of attitude, question items for measuring this intensified degree of attitude were not constructed. Instead, they were based on those question items for measuring attitude towards using a system with the seven-point Likert scale varied by different degrees. Table 3 shows criteria for measuring attitude toward using Facebook.

Figure 6.2.5 reports that the overall reliability is very high and also indicates that there is strong internal consistency among the five question items for measuring attitude towards using Facebook ($\alpha = .899$). This implies that these question items are reliably measuring the same construct and confirms the reliability of the question items for measuring attitude towards using which were adapted from Ajzen and Fishbein [**49**] in Davis, Bagozzi, and Warshaw [**120**].

Based on the results reported in Figure 6.2.6, there is a strong and positive correlation between the scores on the one item and the combined score of the other items ($r > .7$ for ATU1, ATU3, ATU4, and ATU5, and $r > .8$ for ATU2). In addition, the Cronbach's alpha would drop from the overall total of .899 if any question item were deleted. Therefore, all these question items appear to be useful and contribute to the overall reliability of ATU. There is no statistical reason to remove any of these question items.

Attachment (AM). Attachment (AM) is the degree that the user is bonded to the system. While attachment in psychology can be observed in various forms of positive emotion, attachment in Buddhism is just the condition of attachment itself, which is usually unnoticed by the perceiver because it is separated from emotions. This condition always underlies defence mechanisms, which can only be observed when proximity maintenance associated with this condition is influenced. The condition of attachment in Buddhism covers such conditions, which cannot be identified from questions for measuring emotional attachment in

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ATU1	19.84	16.782	.714	.560	.885
ATU2	20.26	15.399	.822	.691	.861
ATU3	20.00	15.575	.730	.546	.883
ATU4	19.90	16.484	.740	.614	.880
ATU5	19.89	16.292	.752	.609	.877

FIGURE 6.2.6. ATU Item-Total Statistics

Items	Descriptions
AM1	I am upset if I am not able to connect to Facebook.
AM2	I find it easy to depend on Facebook to connect with friends.
AM3	I am distressed if Facebook is discontinued.
AM4	It is difficult to imagine life without Facebook.
AM5	It helps to turn to Facebook when I want to connect with friends.
AM6	I am annoyed if Facebook changes the way it looks.
AM7	Facebook really understands me and my needs.
AM8	It makes me uncomfortable if I cannot connect to Facebook.
AM9	Overall, I feel comfortable to have Facebook on my computer.

TABLE 4. Nine items for measuring a condition of attachment towards using Facebook.

psychology (e.g., how much he or she is bonded to the perceived phenomenon). Therefore, a number of questions that have been used to measure emotional attachment in psychology may not be applicable to measure the condition of attachment in Buddhism. Instead, some questions related to separation distress in connection to proximity maintenance may be applicable because they can be used to measure when the condition of attachment itself in human perceptions is influenced. Separation distress has not much been emphasised in the psychological experiment in systems engineering and related disciplines although it was mentioned as a symptom associated with emotional attachment [**155, 312, 341**].

In this case, most question items for measuring the condition of attachment did not ask participants directly how much they were attached to Facebook but were related to when they were separated from Facebook. These question items aimed to measure users' anxiety and certainty or proximity maintenance when they are separated from Facebook. Some questions were also modified from the highly reliable adult attachment scales from the Experiences in Close Relationships-Revised (ECR-R) questionnaire with an excellent rate of the Item Response Theory (IRT) alpha value ($\alpha > .90$). The ECR-R questionnaire is the most widely referred questionnaire on adult attachment, which was developed by Fraley, Waller, and Brennan [**155**] to assess individual differences with respect to attachment-related anxiety and attachment-related avoidance. The validity of the ECR-R scales was measured in Sibley and Liu [**312**]. Table 4 shows nine question items modified from the ECR-R questionnaire for measuring a condition of attachment toward using mobile social network.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.923	.922	9

FIGURE 6.2.7. AM Reliability Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
AM1	37.43	80.407	.739	.630	.913
AM2	36.62	90.127	.563	.439	.924
AM3	37.31	77.876	.805	.713	.909
AM4	37.79	77.115	.815	.731	.908
AM5	36.88	86.010	.601	.456	.922
AM6	37.61	81.297	.731	.591	.914
AM7	37.73	81.238	.740	.612	.913
AM8	37.79	77.983	.801	.718	.909
AM9	36.98	83.883	.707	.547	.915

FIGURE 6.2.8. AM Item-Total Statistics

Figure 6.2.7 shows that the overall reliability is very high and also indicates that there is strong internal consistency among the nine question items for measuring attachment towards using Facebook ($\alpha = .923$). This implies that these question items are reliably measuring the same construct.

Based on the results in Figure 6.2.8, there is a strong and positive correlation between the scores on the one item and the combined score of the other items ($r > .7$ for AM1, AM6, AM7, and AM9, and $r > .8$ for AM3, AM4, and AM8). The Cronbach's alpha would drop from the overall total of .923 if any of these question items were deleted. Although the correlation between the scores on AM2 or AM5 and the combined score of the other items is not as strong as other question items ($r = .563$ for AM2, and $r = .601$ for AM5), this level of correlation is still considered as reliable. Although Cronbach's alpha would increase from .923 to .924 if AM2 were deleted, all these nine question items should be retained because the alpha does not significantly increase from deleting AM2. Therefore, all these question items appear to be useful and contribute to the overall reliability of AM. There is no statistical reason to remove any of these question items.

Intention to Use (ITU). Behavioral intention is an indication of an individual's subjective probability to perform a given behavior. It is widely used in TAM as an immediate antecedent of actual usage of a system [**48, 49, 148**]. Three question items for measuring intention to use were modified from other validated TAM research. ITU is comparable to *cetana*, which is an intention conditioned by attachment or upadana in Buddhism. Table 5 represents three modified question items for measuring intention to use.

Items	Descriptions
ITU1	I intend to use Facebook frequently to connect with friends in future.
ITU2	I intend to use Facebook on a regular basis to connect with friends in future.
ITU3	I intend to use Facebook as often as appropriate to connect with friends.

TABLE 5. Three items for measuring behavioural intention to use Facebook.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.894	.894	3

FIGURE 6.2.9. ITU Reliability Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ITU1	9.83	6.049	.783	.620	.855
ITU2	10.01	5.601	.823	.677	.820
ITU3	9.65	6.333	.770	.598	.866

FIGURE 6.2.10. ITU Item-Total Statistics

Figure 6.2.9 shows that the overall reliability is very high and also indicates a strong internal consistency among the six question items for measuring intention to use ($\alpha = .894$). This implies that these question items are reliably measuring the same construct and confirms the reliability of question items for measuring behavioural intention to use.

Based on the results in Figure 6.2.10, there is a strong and positive correlation between the scores on the one item and the combined score of the other items ($r > .7$ for ITU1 and ITU3, and $r > .8$ for ITU2). Furthermore, the Cronbach's alpha would drop from the overall total of .894 if any of these question items were deleted. As such, there is no statistical reason to remove any of these question items, since all these question items appear to be useful and contribute to the overall reliability of ITU.

Actual Usage. Actual usage of innovations is determined by behavioural intention. There were different questions related to participants' actual usage of Facebook. Participants were asked questions ranging from where they use Facebook to their frequency of using Facebook as associated with different purposes of using Facebook (e.g., sharing images, communicating with friends, playing games, etc.). Actual usage towards innovations is comparable to *kamma* in Buddhism, which is an action determined by behavioural intention.

6.2.4. Procedure. According to the University of Auckland Human Participants Ethics Committee (UAHPEC), the participants must be asked to read the Participant Information

Sheet in order to make sure that they understand the nature of the research before the participants take part in the research. In this research project, however, only a web-based questionnaire was used. Although participants were not required to sign consent forms for the web-based questionnaires, a consent page enabling participants to indicate if they understood what was involved in the research was provided at the beginning of the questionnaire. The participants were informed that they agreed to participate in the research by submitting the questionnaire.

The aim of the questionnaire was explained to the participants to make sure that they were aware of the ethical implications of the research. As the correctness of the answer can be influenced by participant tension [**87, 164**], the participants were informed that it was not compulsory to finish the questionnaire and the questionnaire could be abandoned anytime before the point of submitting the questionnaire. However, a participant's right to withdraw data from the research was not possible since individual participants and their responses could not be identified. The participants were informed that they would not be able to withdraw any provided data after the point of submitting the questionnaire. The participants were informed that the questionnaire took approximately 20 minutes to complete. At the conclusion of the study, the participants were assured that their responses would remain anonymous and confidential and any identifying information such as name, email address, and IP address would not be collected.

The participants were not asked for any information that could be used to identify the participants in the questionnaire. Furthermore, there were not asked for any information that could be used to identify individuals or organisations that the participants worked for. Since it was possible that the participants might accidentally reveal personal information, participants were made aware of the risks before consenting to participate in the research in order to reduce the likelihood. The participants were not asked to give any identifying information in their responses. Any personal or organisational information disclosed was removed. In addition, the data was not publicly available on the Internet and access to the data was limited to the researcher of this research project. The data collected was analysed and reported anonymously. Although complete confidentiality of the responses made from the participants could not be assured because of little control of data privacy on the Internet when using web-based questionnaires, the data collected was not made available on the Internet in order to mitigate this risk. Access to all the data collected for this research project was limited to the researcher of this research project.

6.3. Results and Discussion

The hypothesised model represented in figure 6.1.1 can be considered as a good model fit. All fit indices were within recommended guidelines [$\chi 2$=6.886; $\chi 2$/df=2.295; TLI= .985; CFI= .997; RMSEA= .051; SRMR= .016] [**191, 196, 338**]. The path coefficients (Table 6) linking all constructs in the model are significant at p <.01 level, indicating that these

			Estimate		S.E.	C.R.	P
			Unstandardised	Standardised*			
PU	←	PEOU	.696	.600	.042	16.711	***
ATU	←	PU	.539	.498	.047	11.456	***
ATU	←	PEOU	.238	.190	.055	4.360	***
AM	←	PU	.335	.241	.065	5.158	***
AM	←	ATU	.494	.384	.060	8.215	***
ITU	←	ATU	.229	.198	.045	5.074	***
ITU	←	PU	.384	.307	.047	8.188	***
ITU	←	AM	.372	.413	.032	11.793	***
Usage	←	AM	.094	.147	.032	2.923	.003
Usage	←	ATU	.114	.138	.041	2.768	.006
Usage	←	PEOU	.306	.296	.044	6.916	***
Usage	←	PU	.287	.254	.045	7.213	***
Usage	←	ITU	.104	.146	.039	2.686	.007

TABLE 6. Unstandardised and Standardised Path Coefficients

constructs share statistically significant relationship among each other. These constructs are also positively related to each other.

The results confirm all the DTAM's hypotheses. There is a significant positive relationship between PEOU and PU constructs (.600). Although both PEOU and PU have a positive causal influence on ATU, the relationship between PU and ATU (.498) is significantly stronger than that between PEOU and ATU. These results confirm not only the validity of TAM constructs, but also the structure of the Dhammic framework that *vedana* or attitudes are caused by *nama* or perceived qualities. Attitudes are triggered because qualities are perceived. In addition, the significant positive relationship between ATU and AM (.384) also confirms the Buddhist essence represented in the Dhammic framework that *upadana* or the condition of attachment is caused by *tanha* or an intensified degree of positive or negative attitudes.

Among the constructs that are positively related to the user's behavioural intention towards using Facebook, the relationship between AM and ITU is the strongest (.413) in comparision to other paths, including ATU and ITU (.198), and PU and ITU (.307). The significant positive relationship between AM and ITU also confirms the structure of the Dhammic framework — that *cetana* or intention is driven by the condition of attachment. In other words, it confirms the Buddhist essence that the condition of attachment is central to human behaviours. This significant positive relationship between AM and ITU is the key result of the DTAM experiments, since it also confirms the thesis's main hypothesis that the condition of attachment, which is an insight from Buddhism, can be worth considering in systems engineering and related disciplines. The positive relationship between ATU and ITU is not ignorable, since it confirms the validity of TAM's constructs.

Among the five constructs (i.e., AM, ATU, PEOU, PU, and ITU) that are positively related to the user's actual use of Facebook, however, the relationship between PEOU and

Usage is the strongest (.296). There is also a positive relationship between PU and Usage (.254). Although ITU is not the strongest construct that has a positive relationship to Usage, it still confirms both the validity of the structure of constructs in both TAM and the Dhammic framework that intention influences human actions. It is interesting to note that AM, ATU, and ITU constructs have quite similar positive relationships to Usage at .147, .138, and .146 respectively. Time and innovation, two of the four components of the diffusion of innovations of Rogers [**291**], are considered as two factors underlying the significant positive relationship between PEOU and Usage and the similar positive relationships of AM, ATU, and ITU to Usage. Time affects diffusion in the innovation-decision process and in the rate of adoptions. In addition, there is a time dimension in the innovativeness of a person or other entity of adoption. Different individuals possess different degree of willingness to adopt innovations.

TAM is generally used to measure the user's behavioural intention towards using an innovation in order to predict the likelihood of the innovation being adopted by the user. An innovation in this context is described by Rogers [**291**] as any initiative, practise or development that is recognized as new by individuals or existing units of adoption. An invention may be considered as new, even if it were invented long ago if certain individuals perceive it as new [**291, 295**]. It is the period when the users are deliberate in adopting an innovation. In DTAM measurement, however, Facebook is an innovation that has been attached and used by the users for certain period of time. Facebook may not be considered as an innovation that is sensational to the users. The users are no longer deliberate in adopting Facebook, since they have already used it as part of their daily life. Instead, the users have attached to their attitudes and intentions and become more concerned about usability of Facebook. If the system is more difficult to use than the system that they have been familiar or attached to, they are likely to get offended. This is the symptom of attachment that has been described in logical explanations in the Dhammic framework. This symptom of attachment is described by Rogers [**291**] as 'compatibility'. Rogers [**291**] states that compatibility is a vital attribute in the diffusion of innovations process. Compatibility is the extent to which an innovation is perceived as consistent with the existing ideals, past experiences and needs of prospective users. A lack of compatibility in IT with potential user's needs may negatively influence the individual's IT use [**258**]. The level of compatibility affects the uncertainty and the rate of adoption of the innovation. An increase in compatibility decreases uncertainty.

6.4. Summary

DTAM or TAM with the condition of attachment in Buddhism was the proposed theoretical model to confirm if attachment, an insight from Buddhism can be considered as enhancing the predictability of TAM. Facebook was selected as the technological instrument for testing DTAM. Methodology, including instruments, participants, measurements, and procedures, has been discussed. Question items for measuring participant perceptions towards using

Facebook in accordance with TAM were described. Particularly, those question items for measuring attachment towards using Facebook were constructed in accordance with the condition of proximity or certainty maintenance, which is the noticeable symptom of attachment. For example, how do the participants feel when there are change events to a condition of an attached system such as update, outdate, crash, and termination. Some of them were modified from a well-respected psychological website that measured attachment conditions associated with romantic relationships. The measurement results confirm all of the DTAM's hypotheses and contribute to the confirmation of the TAM structure. The results show that the condition of attachment can be used to predict system acceptance of users and contribute to the confirmation of the main thesis's hypothesis. Given that the condition of attachment is effective for all users, the users can get offended if the innovation is inconsistent with their existing ideals and past experiences as stated by Rogers [**291**]. The next chapter suggests an appropriate path for systems engineering in order to help the system project get accepted by the users under this condtion of attachment.

Part 3

Recommendations and Future Research

CHAPTER 7

The Middle Path in Systems Engineering

> "There is devotion to indulgence of pleasure in the objects of sensual desire, which is inferior, low, vulgar, ignoble, and leads to no good; and there is devotion to self-torment, which is painful, ignoble and leads to no good", Dhammacakkappavattana Sutta [**28**].

7.1. Introduction

This chapter suggests a Middle Path (MP), which is another insight from Buddhism, as a systems engineering path for avoiding attachment conflicts that may offend users and contribute to system project failures. Based on the experimental results in Chapter 6, attachment is a condition that strongly influences behavioural intentions toward using a system. It is an unignorable condition that a system engineer must carefully consider when developing a system. Attachment and ignorance conditions are two sides of the same coin. Although the condition of attachment contributes to significant developments in theories and approaches, it is also associated with many problems. A system engineer, who attaches to his/her own views, usually tends to ignore other views in the meantime. A system can be designed for users in a selfish manner if a system engineer is assertive and inconsiderate to users. When the designed system is inconsiderate to the users, the risk of confrontation between the engineer and the users is high. The high risk of confrontation also means there is a high risk of system project failures. This chapter evaluates how MP theories are effective in addressing attachment conflicts by referring to a conflict resolution perspective. The most appropriate MP for systems engineering is also recommended in this chapter.

7.2. Middle Path (MP)

MP has also long been studied in different bodies of literature as a way of dealing with contradictory attached views. Several MP theories have been applied to deal with conflicts resulted from contradictory attached views. In Buddhism, MP is widely understood among Buddhists as a path that is effective in protecting the person from suffering derived from attachment conflicts. MP is a view that is detached from the identity of a phenomenon. It is a path that is situated between two extreme poles, which is recommended by Buddha to his disciples as a true axiom of all things that protect all humans from being deluded into a condition of attachment. MP is generally used by Buddha to explain the true nature of all things that cannot be defined by either existence or non-existence. According to Buddha, *Majjhima Patipada* or the middle path is the best way to avoid offending others and, at

the same time, avoiding offending oneself. During the awakening of Buddha, he realised that extreme paths didn't work and, hence, the best way was the route of moderation as opposed to over indulgence in self-mortification and/or self-indulgence. In a story found in the Ayacana Sutta, Buddha once debated that humans are so much conditioned by lack of knowledge, greed and hatred that they fail to make out the path of the middle way [**220**]. In Field [**145**, p. 4] , MP is about "avoiding the extremes in our life and finding happiness, joy, and inner peace through the Middle Way". MP is derived from having the 'right view' of a phenomenon. The MP theory is also supported by Ketudat [**223**], who mentioned that technology should be emphasised for sufficiency, but not luxury or greed.

Despite identifying a path in the middle, the meaning of 'middle' is varied and has been used to address conflicts in different contexts. These middle path applications are proposed to provide the most desirable path for all parties in the conflict. According to Guruge [**173**], conflict resolution methods were exemplified and used in practice in Buddhism long before they were identified and denominated in the West. Several conflict resolution methods in Buddhism are comparable to different conflict resolution styles that have been widely studied in different areas in which each has its own strengths and weaknesses characterised by the degree of attachment. In conflict resolution psychology, Goldfien and Robbennolt [**167**, p.280] pointed out that conflict refers to a process through which two or more individuals or parties with differing interests believes that one or the other of the parties is acting in contradiction to the interests of the other. On the other hand, conflict resolution refers to the processes and methods that are conventionally employed in seeing to it that conflicts and disputes are ended. Therefore, conflict resolution can be synonymously used for dispute resolution [**167**, p.277]. In conflict resolution, assertiveness (concern for self) and empathy (concern for others) are dual criteria for classifying conflict resolution styles. This dual model generates different conflict resolution styles attempted to resolve conflicts arising from contradictory attachments. For example, the failure of SET discussed in Chapter 3 initially resulted from competitive conflict style in which the emphasis was laid on assertiveness as opposed to collective interests. Competition is a fighting conflict style that maximises individual assertiveness and minimises empathy (concern for others). By the end, individuals applying this style might offend the other parties and lead to the feeling of intimidation among the other group. Although the SET developer attempted to build a secure system for e-commerce, the secure system was designed from the SET developer's security wisdoms. In fact, the system was not perceived as 'secure to use' by e-commerce end-users. Although this competitive conflict style cannot be categorised as MP, other conflict resolution styles can be used to illustrate how MP has been used as a conflict resolution in the literature.

7.2.1. MP as Conflict Collaboration. In the Art of War, Sun Wu, applies the concept of flexibility as a method of handling every situation in war and the most appropriate way to win on a battle field. "Variation in Tactics/The Nine Variations: focuses on the need for flexibility in an army's responses. It explains how to respond to shifting circumstances

successfully" [**325**, p.1]. Here, the basic principle is that even in case of the competitive style of conflict resolution, one should change his/her style in regard to the situation even if it takes compromise to do so and therefore end up in the Middle Path [**325**]. In Eisley and Tang [**136**, p.254], MP in the Art of War of Sun Wu (or 'Sun Tzu') means a path of flexibility which winds between two radically different poles. These authors state that IT companies are experiencing two paths in systems engineering (all or nothing) and MP is the key principle of Sun Wu's art of war that can be effectively used in IT adoption. This notion of MP is about being flexible in order to survive in the context of contradictory dogmatisms. This context of MP can be classified into the conflict resolution style of collaboration, which comes out as a combination of both pro-self and pro-social agendas. The parties in the arena balance the aspect of satisfying self interests as well as feeling empathetic of the other party. The individuals here are occupied with the sense of assertiveness as well as that of empathy at the same time. The philosophy behind collaboration is that every rational human being should view it in two dimension i.e. the interests of both involved parties as opposed to one dimension i.e. extremity in self and that or of empathy. In this respect, the dedicated members of the involved parties try to iron out the deadlock by actively spelling out their intentions and ideologies behind the dispute or the bond of contention via involvement in collective negotiation aimed at mutual benefit. The individuals here invest in finding a win-win solution to both parties in the conflict which is the biggest advantage of this style. This makes this style to be the most preferable among all others as it ends up satisfying both sides. However, the disadvantage coupled with this style is that it takes the most time compared to other conflict resolution styles [**8**].

7.2.2. MP as Conflict Compromise. The Doctrine of the Mean (or Golden Mean) of Aristotle [**59, 128**] was proposed for identifying the desirable middle between two extremes in a definition. The Doctrine of the Mean was also mentioned in Neo-Confucianism, a Chinese philosophy [**139**], as a way to maintain balance and harmony in extremes. All these concepts are based on the belief that true virtue is situated in the space that is not too extreme or too far to one side. Aristotle taught and believed that virtue has to do with the correct coordination of things in that humans must stand tall and special in the aid of the soul (activity) and reason (knowledge). In this sense, Aristotle philosophically despises egocentrism in cases of conflict and uplifts the styles that encourage the sense of reason, i.e. assertiveness at the same time as empathy. As Aristotle emphasises mutual benefits as a style of conflict resolution, so does neo-Confucianism as it focuses on the humanistic spirit that advocates for both assertiveness and empathy for others as opposed to ego only. This value capitalizes on compromise as a solution to the conflict and hence fairness in agreed deal in conflict resolution. It is advantageous that none losses completely in case of conflict and it is disadvantageous that none gains completely also in case of a conflict.

Despite being inferior to collaboration, compromise is quicker to achieve than collaboration. This style puts all the interests of all parties into account without disadvantaging any

party and therefore within the limits of acceptance. It is a key to industrial civilization as opposed to the ancient Confucianism that was only aimed at the personal aspect and senses of philosophy. This notion of MP as identifying the space in the middle can be found in many applications of systems engineering. It is generally used as an alternative option for how a system should be optimised. For example, Kevin Burton, founder of Web Crawler, described in his personal blog [**10**] that MP was another way of engineering an optimal system. Managing SWAP files in Linux was used to illustrate that MP is an optimal solution due to the significant trade-off of qualities between virtual memory and actual memory. In Taguchi philosophy [**328, 329**], Norminal is Best (NB) is comparable to MP as identifying a path in the middle, which is pointed out as a key criterion for evaluating quality in addition to other two criteria, including Higher is Better (HB) and Lower is Better (LB). Taguchi [**328**] argues that these three system quality evaluation criteria are proposed because not all qualities have the same characteristics for quality engineers.

While MP as identifying a path in the middle may be appropriate for observable attributes, it may not be appropriate for more complicated scenarios that are not easily measured. When the system engineer attaches to the path in the middle, the system engineer may become assertive and inconsiderate to users. MP as conflict compromise can become problematic, since it can be just another attached view in a conflict that requires yet another MP as a compromise. In this case, this notion of MP can be transformed into the conflict competition, which is not undersirable if offending users is the main objective in systems engineering.

7.2.3. MP as Conflict Accommodation. Although MP means a path situated between two extreme poles, two extreme poles in Buddhism can also be interpreted as falling into justifying 'right' or 'wrong' to a phenomenon. It is a path that individual should be mindful to a condition of attachment to right or wrong. Being mindful to a phenomenon is recommended by Buddha as a path that protect all humans from being deluded into a condition of attachment, which can lead to suffering when there are different attached views that are contradictory. The 'Eightfold path' is suggested by Buddha as a mindful path for avoiding the extremes of sensual indulgence and austerity. Johnson [**215**] also supports that the Eightfold path can be used to mitigate dogmatism. The main concept in this Buddhist philosophy is the sense of moderation [**220**]. This moderation context of MP is still comparable to compromise style in conflict resolution, which applies to individuals with intermediate level of self and empathy.

Although the key point of this MP is that Buddhism is a way to change oneself, not others, it also a means to avoid offending others. In this sense, MP in Buddhism may also be viewed as conflict avoidance. An example of MP application can be found in Devadatta Sutta. Devadatta, who was a monk and a brother-in-law of Buddha, tried to propose several strict practices for all monks in order to make himself look more credible than Buddha [**34, 38**].

> "Confronting the Buddha on this issue, Devadatta insisted that he make several practices compulsory for all monks – (1) that they should live only in the forest, (2) that they never accept invitations to eat at devotees' homes but live only by alms gathering, (3) that they wear only rag robes, (4) that they live in the open not in a monastery, and (5) that vegetarianism be compulsory... Devadatta's demands were refused".
>
> In response to Devadatta, Buddha replied [**23**]:
>
> "(1) If they want to live in the forest, as they wish; (2) if they want to accept invitations to eat at devotees' homes, as they wish; (3) If they want to wear only rag robes, as they wish; (4) if they want to live in the open, as they wish; and (5) if they want to be vegetarian, as they wish".

Based on the above quotation, Devadatta's attempt to introduce rules to control other monks was denied by the lord Buddha. Although this MP context can be related to conflict avoidance style in conflict resolution, avoiding offending others in the Buddhist MP context does not mean to ignore conflicts like conflict avoidance in which individuals involved have low or less concerns on their self as well as the concerns of the other involved parties. It is worth noting that people who prefer conflict avoidance style usually adopt the hands free attitude as they wait for the situation to be sorted out by itself without personal effort. This style of conflict resolution is characterised by letting the events unfold. In cases of the progressive development of conflict, the conflict might go out of control [**69**]. This conflict ignorance style may move to stage of avoidance-avoidance conflict [**2**], which is a psychological conflict when a choice must be made between two undesirable solutions.

Instead of interpreting Buddhist MP as conflict avoidance, it should be viewed as a non-confrontational approach for addressing problems by avoiding potential issues that might affect the relationships involved. MP in this context can be a goal-directed behaviour rather than a behaviour that reflects passivity or inaction. It is a strategic conflict resolution style that aims to maintain peaceful relationships by avoiding offending others, but confront when appropriate. According to Guruge [**173**, p.13-14], the notion of Buddhist conflict resolution is based on "one should think of others in comparison with ones own self...Acts of individuals should comply with the interests of the society". This conflict avoidance style in Buddhist MP context is also understood in conflict resolution as the accommodation (yielding) style coupled with increased concern for others and diminished concern for self interest. This approach is taken as passive and pro-social as the individual derives self satisfaction through serving others and meeting their needs and hence up with stable social relationship and boosting the unity among the members of the group (organization). In eventuality of a conflict, the individuals involved here give in to the demands of others for the well being of unity and social relationships owing to the conviction that the unity of the community is more important than one's self interests [**153**]. This style is advantageous in that one controls the conflict from worsening by giving in to the demands of others.

7.3. Buddhist MP Systems Engineering

> "Monks, these four types of kamma have been directly realized, verified, & made known by me. Which four? There is kamma that is dark with dark result. There is kamma that is bright with bright result. There is kamma that is dark & bright with dark & bright result. There is kamma that is neither dark nor bright with neither dark nor bright result, leading to the ending of kamma" [**39**].

In order to avoid affecting the user's attachment or offending the user, the user's 'neutral' attitude is suggested as the goal of systems engineering, which can be considered as Buddhist MP systems engineering. Although it would be better if a system engineer could make use of users' positive attitudes, developing a system that the user has a positive attitude may not always be desirable. There is always a chance of offending the user, since the condition of attachment is subjective. Based on logical explanations in the Dhammic framework in Chapter 5, either positive or negative attitudes toward a system will lead to a condition of attachment, which can contribute to desirable or undesirable outcomes in systems engineering. The user's defence mechanism will be triggered in order to protect his or her secure attachments if the user's attachment is affected. When the system is rejected by the user, there is no guarantee how long the user's defence mechanisms will remain because the temporal stability of attachment is also subjective. This will also affect the system engineer, who can be deceived into *samsara* or an infinite problem-solving state. For example, a number of SET extensions proposed to address SET implementation issues implied that SET developers attempted to compromise, but it was too late when users had already been offended.

In contrast, the perceived system will be neither craved for sensuality nor craved for non-being if a user's attitude to a new system is 'neutral'. Although the notion of neutral in Buddhism is a condition, which is separated from positive and negative feelings, it is not applicable to systems engineering context overwhelmed with people, who are conditioned by different attachments. As such, the term 'neutral' in this context means the condition of attachment that the user has been satisfied and familiar, but cannot be expressed in 'like' or 'dislike'. In other words, building a system based on what the condition that the user has already been satisfied may be a promising path in systems engineering in addition building a system based on what to satisfy the user. The system engineer, who follows Buddhist MP systems engineering, will aim to change the system in such a way that it will minimally offend users. It is a path that the system engineer attempts to avoid contradictory dogmatisms. Based on the case of SET failures, the story might have been different if SET has been designed in the same way as 3D SET where all SET security requirements could be handled by the 3D architecture without offending users. How Buddhist MP can benefit systems engineering is described using the six following scenarios starting from when one system has been attached by a user ($\forall\, u : user \mid \exists\, s : system \bullet u \mapsto s \in upadana$).

(1) A user who has attached to one system state feels neutral to a new state of a system ($\forall\, u \mapsto s \in upadana \mid \exists\, s? : system \bullet u \mapsto s? \in uppekha$). The user does not feel either positive or negative to the new state of the system. The new system state is not contradicted to the system state that has already been attached to by the user.

(2) The new system state will not be craved for sensuality or non-being by the user because the user does not have positive or negative attitude toward the new system state ($\forall\, u \mapsto s \in upadana;\ u \mapsto s? \in uppekha \mid \neg\, \exists\, s? : system \bullet u \mapsto s? \in kamatanha \wedge u \mapsto s? \in vibhavatanha$). Although the new system state is not craved to adopt, it is also not craved to reject by the user.

(3) The new system state will not be attached for security or insecurity by the user because the new system state is not craved for sensuality or non-being by the user ($\forall\, u \mapsto s \in upadana;\ u \mapsto s? \in uppekha \mid \neg\, \exists\, s? : system \bullet u \mapsto s? \in upadana \wedge u \mapsto s? \notin upadana$). Although the user does not attach to the new system state because the new system state is not craved to adopt, the user does not attach to the new system state as unwanted because the new system state is not perceived as being offensive to the system state that has already been attached by the user.

(4) The new system state is integrated with the attached system state because the new system state is not perceived as being offensive to the system state that has already been attached by the user ($\forall\, u \mapsto s \in upadana;\ u \mapsto s? \in uppekha \mid \exists\, s, s? : system \bullet u \mapsto [s/s?] \in upadana$). In other words, the new system has become part of the user's attachment without offending the user.

(5) There is no intention to adopt or reject the new system state because the new system state is not attached for security or insecurity by the user ($\forall\, u \mapsto [s/s?] \in upadana;\ u \mapsto s? \in uppekha \mid \neg\, \exists\, s? : system \bullet u \mapsto s? \in cetana \wedge u \mapsto s? \notin cetana$). Although there are no behavioural intentions to use the new system state, there are no behavioural intentions to reject the system. In other words, the user's defence mechanism is not triggered because the new system state is not perceived as being offensive to the system state that has been attached by the user.

(6) There is no action to adopt or reject the new system state because there is no intention to adopt or reject the new system state ($\forall\, u \mapsto [s/s?] \in upadana;\ u \mapsto s? \in uppekha \mid \neg\, \exists\, s? : system \bullet u \mapsto s? \in kamma \wedge u \mapsto s? \notin kamma$). Although the user does not adopt the new system state, the new system state is not rejected by the user because the user's defence mechanism is not triggered.

Based on above scenarios, the Buddhist MP is a path that is aimed to avoid offending the user, who has already attached to a particular system. The system engineer can use the user's neutral attitudes in order to avoid the user's negative attitudes toward the proposed system in such a way that the user's attached system state will not (or minimally) be affected. The proposed system can integrate with the user's attached system if the user is not offended by the proposed system. This notion of Buddhist MP systems engineering is consistent

with several theories in Human Computer Interaction or HCI that have been proposed from different disciplines (e.g., social sciences, cognitive psychology, etc.) in order to promote how a system should be engineered in accordance with user behaviour towards using the system. Some of them were intended to avoid offending users or affecting user attachments, which are coherent with the notion of Buddhist MP systems engineering.

7.3.1. Considerate Systems. The notion of considerate systems proposed by Selker [**308**] is a systems engineering theory aimed to avoid offending users that is consistent with Buddhist MP systems engineering. The philosophy behind considerate systems is that social understanding must be integrated in systems engineering. According to Selker [**308**, p.1], "system must be adaptive and recognise and learn appropriate times and approaches to communicate a request or provide other feedback". Disruptions and interruptions were distinguished by Selker [**308**] to explain how a system should be designed. Interruption is used as positive term when there is an interrupting signal that assists and supports a user in accomplishing the task. An interrupting signal does not offend a user and helps a user accomplish the task more effectively. In contrast, disruption has a negative meaning and occurs when there is an interrupting signal changing the topic a user is attending to. Selker [**308**] claims that a user's negative perception of a system can be mitigated if a system is engineered to avoid disruption and pay attention to appropriate interruptions. Selker [**308**] further points out that feedback is an important element of social responses that validates the level of user understanding. Social responses integrated into a system must be modeled in a polite manner just as when we communicate on a daily basis. There are different degrees of politeness. Physical and emotional detections such as eyelid and voice recognition are examples of elements of considerate systems that can be used to understand when and how the system should interact with a user. An interaction with appropriate behaviour is the key element of considerate systems. The author concludes that "considerate systems must hold up their side of an interaction with appropriate behaviour. A considerate system must be able to present itself with the adequate social aspects for the stage of an interaction it finds itself in" [**308**, p.9].

7.3.2. Polite Computing. This notion of Buddhist MP systems engineering can also be illustrated by the theory of polite computing proposed by Whitworth [**358**], which is a social control to computer human interaction. There are three main criteria in polite computing: 1) the user's choices are respected; 2) only useful choices are offered to the user; and 3) any important past choices are remembered. Politeness in computing means any practice in computing where all the users are seriously taken into an account. It is a fundamentally accepted concept but it should be remembered that polite computing actions vary in different cultures. The globally accepted form of polite computing is the goal it achieves. Similar to the notion of Buddhist MP systems engineering, polite computing does not pay much attention to the specific behaviors of a system as shown in the information system task concept [**134**].

Politeness is the ability to be with the rest in any social gathering than in situations when you are not. Whitworth [**358**] points out that being polite is different from being etiquette which tends to be more specific oriented. Therefore, the utmost rule of politeness is agreeing to another person's praise without compromise whatsoever.

Polite computing practice offers a choice to the computer users while impolite computing offers no choice. Impolite computing therefore is the undesired action that shifts the mind of the computer user from the normal operation. For example, an abrupt pop up window that forces the computer user to look at a different thing from his or her main point of focus [**151**]. This means the user's choice to view the articles of his or her choice is denied. This in computer terminologies cannot be termed as illegal but it is considered impolite. Whitworth [**358**] asserted that many users do not want their computer screens to be commanded by annoying pop-up windows that must be closed from time to time. Spam emails are another form of impolite computing because it occupies inbox space without the user's consent [**65**]. Numerous computer users will attempt to fight back, if it persists, they may reduce the time they take when browsing or emailing. Any software that secretly retrieves that computer user's information without his or her knowledge and modifies it will be engaging in impolite computing. Impolite computing will drive away the users as they feel dictated to and may eventually lead to system project failures. The philosophy behind polite computing is that there are no globally agreed standards to guide it. It is up to the computer users to demonstrate behaviors that do not disturb any of the parties using the computer. Applying computer politeness by always considering the user's choices is the most important thing in all corporate businesses aspiring to grow [**65**].

7.3.3. Agile Software Development. Agile software development [**110, 184, 254**] is a theoretical framework or empirical process for several software development methods, based on iterative and incremental development (IID) [**233**], in response to the uncertain nature of software development (e.g. changing requirements and new technological advancements).

Agile software development was inspired by the Agile Manifesto [**9**], which provides alternative ways of developing software more effectively than waterfall software development. According to the Agile Manifesto [**9**], there are four principles for developing software: 1) Individuals and interactions over processes and tools; 2) Working software over comprehensive documentation; 3) Customer collaboration over contract negotiation; and 4) Responding to change over following a plan.

Agile was introduced to address several issues with waterfall software development; waterfall is not flexible, due to its strict sequential phases of software development [**110, 254, 371**]. There are several benefits to using Agile. Firstly, communication and coordination among team members can be improved. Secondly, the flexibility of Agile is such that developers can adjust the software project in accordance with users' changing requirements immediately.

Therefore, the cost of change in software development can be much less than that with waterfall, chiefly because of the iterative software lifecycle, which allows the developer to adjust the system in accordance with evolving requirements.

In addition to software development, Agile paradigms can be used more generically as a conflict resolution style. Feiler [**142**] describes how Agile development paradigms, including communication, adaptation and awareness, can be applied to areas of life such as raising children and household management. Feiler [**142**] claims that the application of Agile paradigms can bring significant improvements to the household environment.

Several Agile methods have been proposed. Among these, XP (Extreme Programming) [**70, 110, 184**] and Scrum [**112, 303**] are the most widely used methods that have been adopted in practice.

XP. In XP [**70, 110, 184**], a 'small prototype' or 'demo-able', a kind of pre-release software, must be released every few weeks to allow progressive checks on software quality until the end of the process. This allows the software developer to evaluate feedback and address coding issues during the software development process.

An initial planning phase of XP is 'user stories', in which users describe the needs of software in writing. Software developers can estimate the time and resources required to build the small prototype from the initial requirements obtained from user stories. The small prototype must be flexible so that further requirements can be added to the software product. The quick release of the small prototype is another advantage of XP, because it makes the software project easier to assess.

The small prototype will go to an iteration phase, where acceptance tests are performed in accordance with user stories. The output of each iteration is working code, which can be used to evaluate and respond to changing user requirements. In this case, the users can verify all results against the small prototype that the developer defined from requirements.

This iterative process will continue until the software project becomes stable. When the user is satisfied with the software features, the developers can decide if they want to: 1) Terminate the iteration phase in order for the software product to move to a post-release phase or 2) Terminate the software project before all of the originally planned user stories are implemented.

Scrum. Scrum [**112, 303**] is another Agile method, based on rapid prototyping with responsiveness to rapid changes during development. It came about because developers wanted a methodology in which incomplete requirements are not limited to the initial phase, but can be incorporated into all software development phases.

Scrum includes both management and development processes; each department has responsibility for the developing process. At the beginning, the user is required to create and prioritise the 'Product Backlog' (requirement) before choosing the 'Sprint', that is, those

features to be included in the next 30 days of the software development project. The development team will plan the tasks and resources required to deliver a certain number of features to be included in the next Sprint.

During the Sprint, the software code is integrated and tested daily. Everyone responsible for developing software is required to attend the Scrum daily meeting for 15 minutes, in order to discuss potential aspects that could improve the development of the software project. This daily meeting allows members to talk about the progress of the software project, and also encourages members to pay attention to other members' situations; the project must be approached as a collaborative effort.

At the end of the Sprint, the progress of the software project (functions, issues, strengths, and weaknesses) will be reviewed and demonstrated to the user. After this, the cycle will begin again from the initial phase, where the next 'Sprint', or features to be included in the software, will be chosen.

7.4. Summary

Different MP theories have been discussed in this chapter in connection to modern conflict resolution styles in psychology. The concept of MP is the classical and philosophical way of conflict resolution that has long been suggested in various disciplines as a path to deal with conflicts in order to satisfy parties involved in the conflicts. The MP theory is supported by most of the ancient philosophers of the time (e.g., Gautama Buddha the founder of Buddhism, Aristotle the great Greek Philosopher, and Neo-Confucianism). Although there are different applications of MP, they are aimed to maintain a humanistic and peaceful aspect in a group as opposed to extremisms. As such, competition, which is one of conflict resolution styles, has never been regarded as MP. On the other hand, MP applications have been used as a path to collaborate, compromise, and accommodate conflicts in the most amicable way without going overboard.

Despite being regarded as the path of the peace and harmony, MP applications are varied in maintaining the peace in systems engineering. There are potential issues that may trigger the user's attachment or offend the user. For example, it is difficult to satisfy two parties on opposite extreme poles having different attached views although MP as collaboration is highly recommended in the literature because of its win-win goal. This time-consuming factor may offend and cause negative attitudes to the user. Furthermore, MP as compromise can be subject to fall into the condition of attachment and transformed to competitive conflict resolution style although identifying the path in the middle has been widely used to compromise conflicts, i.e., the user attaches to his or her views and does not lean to the system engineer, who attaches to the path in the middle and vice versa.

In Buddhism, two criteria for classifying conflict resolution styles such as assertive and considerate are insufficient to describe two extreme poles in Buddhism based on the condition of attachment (e.g., right or wrong, yes or no, like or dislike, etc.). The system engineer, who

attaches to his or her views about systems engineering, may be considered as inconsiderate and ignorant although the system engineer might be considerate to the user. In order to get the system project adopted by the users, 'self' must be ignored in order to maintain the peace. Therefore, Buddhist MP categorised into accommodation conflict resolution style is recommended as another promising path for systems engineering, since it is the path that aims to avoid offending the users that may be resulted from the system engineer's attached views. This notion of MP as conflict accommodation is supported by systems thoeries such as considerate systems and polite computing that aim to avoid offending users.

Although the Agile philosophy and the MP in systems engineering stress flexibility in adapting to circumstances in order to avoid offending users, there are some significant differences between the two. While Agile emphasises frequent collaborations between the developer and the users in order for the development of software project to parallel changable users requirements, the MP focuses on how the software itself will be designed, in such a way that it will not offend the users, who have attached to their behavioural usage of the software.

Despite the benefits of using Agile methods, criticisms related to collaborations and communications have also been reported [**171, 187, 237, 321**]. For example, Agile is not appropriate for a large software development project requiring more than 10 people, since it can be difficult for people with different ideas to collaborate in the software development team. The number of required meetings in the Scrum method has also caused frustrations for some people who need to report progress. In some cases, work cannot get done on time because members are not familiar with the software project and with other members. As such, the progress reported to the team may not actually represent the real progress, which can affect the quality of the software project.

The user stories process in XP has also been criticized [**171, 321**], because of its shortness and vagueness. It can only be effective if there is a user representative who reviews and approves user story implementations. However, relying on the user representative in a large project may offend other users, who might come up with different ideas after previous requirements have been summarised to the developer. Since 'responding to change over following a plan' is one of the major principles of Agile, scaleability has become another criticism of Agile, resulting from its flexibility in responding to changing software development. It is difficult to predict when, after the requirements have become stable, the final prototype can be released. All these criticisms imply that significant chances of offending the users remain, despite a number of improvements in software development.

CHAPTER 8

Conclusions and Future Research

> "The religion of the future will be a cosmic religion. It should transcend personal God and avoid dogma and theology. Covering both the natural and the spiritual, it should be based on a religious sense arising from the experience of all things natural and spiritual as a meaningful unity. Buddhism answers this description. If there is any religion that could cope with modern scientific needs it would be Buddhism", Einstein [**135**].

8.1. Introduction

The thesis has theoretically, logically, and practically illustrated that the condition of attachment is worth considering in systems engineering and related disciplines. The condition of attachment has been pointed out as the root cause of system project success or failure, since it can cause a positive or negative effect in systems engineering. The condition of attachment is associated with compete theories and approaches in dealing with complexity in systems engineering. For example, requirements engineering was introduced to improve the quality of requirements when poor quality of requirements were pointed out by researchers and practitioners as the root cause of systems failures. A number of system quality frameworks were proposed to improve different quality aspects of a system. A more specific field of systems engineering such as security engineering was invented to address potential threats to a system when security was the main goal for systems engineering.

On the other hand, the condition of attachment can be considered as the root cause of system project failures because it is pre-conditioned by positive or negative attitudes and influences human behaviours. The condition of attachment always underlies how a system engineer designs a system and how a user adopts or rejects a system. A case study of SET was used to explain reasons behind SET failures associated with a condition of attachment, including the emergence of SET, problems of SET, and attempted solutions of SET. SET was designed from attached views of SET security engineers, who believed that strong security mechanisms used in the SET scheme can prevent potential threats to e-commerce. In contrast, the elegant security architecture of SET caused a number of significant problems. Attached security design views of SET developers offended e-commerce participants, who were attached to how they viewed the e-commerce system. Although several SET extensions were later proposed to address criticisms raised against SET, e-commerce participants has already attached negative views to SET. SET developers could no longer sustain their efforts for the survival of SET.

The Dhammic framework, an original framework based on psychological constructs in Buddhism, was constructed to logically represent the role of attachment underlying how a system user perceives and justifies a system. A number of doctrines related to states of mind in Buddhism were formalised in the Z schemata in order to understand discourses associated with different states of mind. Logical arguments in the framework illustrated how a condition of attachment could be undesirable in systems engineering. A system would be accepted or rejected depending upon user behavioural intentions driven by a condition of attachment. As such, a condition of attachment was further investigated in theories and approaches related to system acceptance.

This thesis proposed DTAM or Dhammic TAM, which is an extended version of TAM with the condition of attachment. A number of question sets were developed to measure user perceptions of Facebook in accordance with the TAM and the Dhammic frameworks. A condition of attachment was located in between attitudes towards using and intention to use as posited by the Dhammic framework. The experimental results showed that most psychological constructs widely used in TAM were correlated with a condition of attachment. Particularly, the result also represented that there was a stronger correlation between attachment towards using and intention to use than attitudes towards using and intention to use. The result confirms the hypothesis that the condition of attachment, which is an insight from Buddhism, can be worthy of consideration in systems engineering and related disciplines.

MP or Middle Path, which is also an insight from Buddhism, was discussed with the notion of MP from other disciplines in dealing with conflicts. These MP theories were discussed in reference to conflict resolution styles. Although competition is considered as one of conflict resolution styles, it is not regarded as MP but something that a system engineer aiming for MP must be mindful of. Although some MP theories are comparable to conflict resolution styles, Buddhist MP was recommended as a proper path for systems engineering in order to avoid attachment conflicts or offending users. Buddhist MP is related to accommodation style in conflict resolution, which is consistent with prominent system theories such as considerate systems and polite computing in which the main goal is to avoid offending end-users.

8.2. Contributions of this Thesis

This thesis provides a novel analytical framework for understanding system project failures from Buddhist insights. This thesis reveals that the cause of system project failures can be rooted in a condition of attachment inside the mind and suggests how to deal with this cause. The theory is different from most existing theories related to systems engineering in which external causes are emphasised and have proliferated in the literature. Although Moody [**268**] suggests that a unified framework is required due to the proliferation of such frameworks, it is still a complicated process to construct a unified framework from such different factors. Since the Dhammic framework is based on psychological constructs inside the mind, the framework is not restricted to a particular system. Therefore, the Dhammic

framework can be reproduced and applied to analyse all system project failures to see if the cause of problems is rooted in attachment conflicts.

The emphasis of the Dhammic framework on individual perceptions to a system is closely related to Cognitive Informatics (CI). CI is a transdisciplinary approach to the cognitive and information sciences which emphasises the informational aspects of cognitive processes with applications in the engineering of complex systems. According to Wang [**351**], CI is "the transdisciplinary enquiry of cognitive and information sciences that investigates into the internal information processing mechanisms and processes of the brain and natural intelligence, and their engineering applications via an interdisciplinary approach". Bo Zhang, in a recent position statement at a major CI conference, argued that "CI should benefit from the multidisciplinary research among information science, cognitive science and brain science, etc." [**354**, p.18]. The emergent CI framework is a logically coherent synthesis of well-accepted theories from cognitive science and psychology. Constructs in these theories represent how information is processed as objects, attributes, and relations [**352**] in a layered reference model of the brain (LRMB) [**353**] with thirty-seven cognitive processes at six levels: Sensation, Memory, Perception, Action, Meta-Cognition, and Higher Cognition. This theory posits some very specific connections between sensation, memory, perception, action, and meta-cognition.

In a recent article by Jarupunphol and Thomborson [**212**], the Dhammic framework illustrated how some of the fundamental concepts in Buddhist epistemology may be modeled in the CI framework. The Dhammic framework represents a logical specification, in the Z notation, of cognitive processes which occur at levels 1 through 4 of the Layered Reference Model of the Brain (LRMB). As with any axiomatic system, the validity of the Dhammic Framework cannot be proved by experimentation; but it could be invalidated if any of its implications were either logically inconsistent or in disagreement with experimental observation. The formal statement of the Dhammic Framework allowed its axioms to be tested, scientifically, for contradiction within the framework of cognitive informatics. The theory can be considered as scientific in the Hopperian sense of being falsifiable, since psychological constructs in the Dhammic framework can be tested empirically. Although this article has not provided clear technical contribution in form of clear definition of the framework to CI, logical arguments used to represent psychological constructs from Buddhist insights contribute novel aspects of human perceptions to the theoretical framework of CI.

Furthermore, this thesis investigates the condition of attachment and points out how the condition of certainty maintenance is related to the users' behavioural intention to use the system. While TAM is the most widely used model for predicting the likelihood of a system being accepted or rejected by the user, the measurement results of DTAM shows that the condition of attachment is not ignorable and can be considered as another construct of TAM, since the results show that the condition of attachment has a stronger influence on intention than attitudes toward behaviour. This implies that the attempt to engineer a

system without paying attention to the condition of attachment of users may be disastrous for system projects.

Since the condition of attachment, which is an insight of Buddhism, is valid, MP, another Buddhist insight, can also be taken into account in systems engineering. MP systems engineering was proposed as the most appropriate style for avoiding system project failures resulted from affecting user attachments or offending users. Although the notion of Buddhist MP is not novel in systems engineering and has long been associated with different system theories, it has never been recognised and translated into a number of terms and modern conflict resolution styles. MP is a classic conflict resolution theory that aims to create peace by satisfying parties involved in conflicts. MP applications are related to some conflict resolution styles, but not all conflict resolution styles are regarded as MP. The thesis has revealed that Buddhist MP is a universal conflict resolution mechanism with the intent to avoid offending a social system. Any theory, which is consistent with this definition, can be considered as Buddhist MP.

Bartolomei [**68**] points out that the functional domain, technical domain, process domain, social domain, and environmental domain are all important for developing a framework for systems engineering. The Dhammic framework for systems engineering is based on the personal domain that represents how the system is perceived through the user's states of mind and how the condition of attachment underlies the user's behavioural intention and action to the perceived system. However, the emphasis on the personal domain based on Buddhist insights contributes to the notion of Buddhist MP systems engineering, which is about how the system should be engineered for users given that the condition of attachment is applicable to all individuals. In other words, the emphasis on the personal domain of the Dhammic framework contributes to Buddhist MP systems that emphasises two crucial domains in systems engineering, including the social domain and the environmental domain.

8.3. Limitations of the Thesis

> "Monks, there are these four perversions of perception, perversions of mind, perversions of view. Which four? 'Constant' with regard to the inconstant is a perversion of perception, a perversion of mind, a perversion of view. 'Pleasant' with regard to the stressful... 'Self' with regard to not-self... 'Attractive' with regard to the unattractive is a perversion of perception, a perversion of mind, a perversion of view. These are the four perversions of perception, perversions of mind, perversions of view", Vipallasa Sutta [**32**].

The quotation above implies that there are limitations related to subjective human perceptions. Although the Dhammic framework shows a precise structure of psychological constructs underlying the condition of attachment from a Buddhist perspective, the framework itself still cannot be used to address attachment conflicts. Despite the fact that the condition of attachment is situated between intensified degree of attitudes and behavioural intention,

each individual's attachment is different because the condition of attachment is subjectively constructed. As logically illustrated in the Dhammic framework, a system does exist without an initial contact between a user and a system. The condition of attachment arises because physical properties, qualities, and attitudes are triggered after the user and the system have contacted. This means that users do not share the same attachment to the perceived system. Limitations of the framework can be illustrated below.

Limitation 1:: Although all users contact a system, it is not the case that a system perceived by one user is similar to that perceived by another user ($\forall\, u \mapsto s? \in phassa \mid \exists\, u_1, u_2 : user \bullet u_1 \mapsto s? \in rupa \neq u_2 \mapsto s? \in rupa$). In reality, this limitation is always valid because there is no case where one user is the same as another user.

Limitation 2:: Although all users perceive a system, it is not the case that a quality perceived from the system by one user is similar to that perceived from the system by another user ($\forall\, u \mapsto s? \in rupa \mid \exists\, u_1, u_2 : user \bullet u_1 \mapsto s? \in nama \neq u_2 \mapsto s? \in nama$). This limitation arises as a result of the previous limitation. One user may perceive the system as easy to use while another perceives the system as complex to use.

Limitation 3:: Although all users perceive a quality from a system, it is not the case that an attitude towards the system of one user is similar to that of another user ($\forall\, u \mapsto s? \in nama \mid \exists\, u_1, u_2 : user \bullet u_1 \mapsto s? \in sukha \wedge u_2 \mapsto s? \in dukkha \mid u_1 \mapsto s? \in sukha \wedge u_2 \mapsto s? \in uppekha \mid u_1 \mapsto s? \in dukkha \wedge u_2 \mapsto uppekha \bullet u_1 \mapsto s? \in vedana \neq u_2 \mapsto s? \in vedana$). The user, who perceives the system as easy to use, has a positive attitude towards the system. On the other hand, the user, who perceives the system as complex to use, may have a negative attitude towards the system.

Limitation 4:: Although all users have attitudes towards a system, it is not the case that all of them have the same craving towards the system ($\forall\, u \mapsto s? \in vedana \mid \exists\, u_1, u_2 : user \bullet u_1 \mapsto s? \in kamatanha \wedge u_2 \mapsto s? \in vibhavatanha \bullet u_1 \mapsto s? \in tanha \neq u_2 \mapsto s? \in tanha$). The user, who has a positive attitude towards the system, craves to the sensual pleasure received from the positive attitude. On the other hand, the user, who has a negative attitude towards the system, may crave for non-being of the negative attitude.

Limitation 5:: Although all users have cravings towards a system, it is not the case that all of them have the same attachment to the system ($\forall\, u \mapsto s? \in upadana \mid \exists\, u_1, u_2 : user \bullet u_1 \mapsto s? \in upadana \neq u_2 \mapsto s? \in upadana$). The user, who craves to the sensual pleasure from the system, attaches to his or her views that the system has a quality that is capable of fulfilling his or her desires. In other words, this is the condition of secure attachment in which the user feels secure to use the system. On the other hand, the user, who craves for non-being of the system, may attaches

to his or her views that the system has a quality that is capable of causing his or her aversions. This is the condition of insecure attachment in which the user feels insecure to use the system.

Limitation 6:: Since there is the user, who feels secure attachment to the system, and the user, who feels insecure attachment to the system, it is not the case that all of them intend to adopt the system ($\forall\, u \mapsto s? \in cetana \mid \exists\, u_1, u_2 : user \bullet u_1 \mapsto s? \in cetana \neq u_2 \mapsto s? \in cetana$). The user, who feels secure attachment to the system, tends to adopt the system because he or she attaches to his or her views that the system has a quality that is capable of fulfilling his or her desires. On the other hand, the user, who feels insecure attachment to use the system, tends to reject the system because he or she attaches to his or her views that the system has a quality that is capable of causing his or her aversions. In other words, the user's defence mechanism is triggered when the user feels insecure to use the system.

Limitation 7:: Since there are different intentions toward the system, it is not the case that all users adopt the system ($\forall\, u \mapsto s? \in kamma \mid \exists\, u_1, u_2 : user \bullet u_1 \mapsto s? \in kamma \neq u_2 \mapsto s? \in kamma$). The user adopts the system because he or she intends to adopt the system that is capable of fulfilling his or her desires. In contrast, the user rejects the system because he or she intends to rejects the system that is capable of causing his or her aversions. The triggered defence mechanism of the user will condition the user's action in response to the system.

In addition to above limitations related to the subjective nature of human perceptions, there are potential limitations related to framework applications. The emphasis of the Dhammic framework on the personal domain and the emphasis of Buddhist MP systems engineering on the social domain and the environmental domain can be potential limitations. Although Buddhist MP systems engineering has nothing against systems engineering theories and approaches in the literature, MP systems engineering may not be desirable for systems engineers, who are less concerned about usability than users and prefer to build a system from their own technical attachments [**217**]. In this case, the framework may not be agreed to by those systems engineers who attach to a competitive conflict resolution style that complexity must be controlled.

Another limitation is that Buddhist Dhamma has been subjectively interpreted from time to time, the Dhamma has been differently perceived by Buddhists. This also includes a number of states of mind that have been differently understood and interpreted. Since the condition of attachment is subjective, it also implies that the framework may not convince Buddhist systems engineers who follow the Dhammic framework but attach to their own interpretations about states of mind. Although Buddhism is a philosophy of detachment, it could be said that Buddhism has become one of the largest group of dogmatic believers in the world, who attach to rules and rituals, but not perceptual conditions in Buddhist Dhamma. In this sense, the framework may not be supported by Buddhists, who attach to what they

believe. It is likely that a system will be analysed in a dogmatic fashion without critical evaluation of states of mind.

This thesis recommends Buddhist MP systems engineering as the most appropriate path for dealing with attachment conflicts. However, the intent to accommodate and avoid offending users can be another potential limitation. Although the main goal of Buddhist MP systems engineering is to get the system accepted by not offending the user, overemphasis on avoiding upsetting the user by ignoring desirable system properties that must be delivered may be misused by the system engineer, who uses the MP path for his or her own benefits. For instance, the system engineer may not be knowledgeable of the system, but use MP systems engineering in order to reach the goal. The system engineer may also claim there is a significant improvement in a system because avoiding affecting user attachment is the primary focus, while there may have been no or minor improvement in the system. To make the matter worse, the system engineer may gradually impose his or her preferred functionality in such a way that the user does not notice. The user can gradually be controlled by the system engineer and may eventually realise that he/she is fully controlled when it is too late. The systems engineer can gradually use an MP path to control users without offending users. This is comparable to Anderson's previous concerns [**54, 55**] regarding TC (discussed in Chapter 2) that system owners can use TC to gain controls over system users. Indeed, articles in late 2011 [**159, 239**] pointed out that TC used in Window 8 Secure Boot may not permit competitive products to be installed on the same machine, which confirm Anderson's statements.

Dealing with cultural factors in systems engineering is also an example of Buddhist MP systems engineering which attempts to avoid offending users who attach to their own views and beliefs and will defend them if they are offended. There are a number of articles pointing out that understanding culture is crucial in software development [**81, 228, 251, 262**]. There are major obstacles of IT adoption influenced by cultural factors when conducting a negotiation of business projects [**228, 251**]. For example, power distance is one of the major obstacles effecting the efficiency of business flow. The business process is influenced by many cultural factors caused by organisational members. The culture and perceptions of these organisational members are cultivated by their social context that result in dissimilarities of cultural factors in different countries. The cultural factors play an important role in the adoption of IT but can result in undesirable outcomes if they are ignored [**178, 213**]. Culture is a dominant factor influencing people's ways of perceiving the world. The same thing can be differently interpreted by people, who come from different cultures despite sharing the same language. In Yuan et al. [**369**], cultural impacts on intergroup coordination in software development in China was studied. These authors pointed out that differences restricting intergroup coordination in software development exist both in languages and cultures and contribute to potential confusions. There are a number of sensitive factors formed by the culture. These sensitive factors formed by one culture may be different from those in another

culture. Because each culture is effective and applicable for a particular domain, a system, which is appropriate for one culture, may be considered as offensive in another culture. Privacy is an example of a culturally formed notion. While privacy has been suggested as another essential aspect in the information security literature [**257**], it is clear that there are some mismatches of privacy in information ethics between East and West — and cultural factors appear to be the dividing issue [**190**]. For example, the definition of privacy in Western countries is often different from and inappropriate in the Thai context [**225**]. Privacy may be an issue of concern for people from European countries, but not Thai people, who are often concerned about other people's way of life. Not respecting other people's privacy is commonly found in Thailand. When the culture is formed by hierarchical power, demanding privacy can also be considered as offensive to superior officers in Thailand. According to Kittiyadisai [**225**, p.21], 'Thai officials still exhibit the Sakdi-nar attitude of being in a 'high place' (tee-soong), so that they have a 'superior right' to access or make use of all official supplies or instruments, including personal data in the database within their range of command'. A system designed to limit the official access to personal data may be considered as offensive and get rejected by the officials.

Another limitation of the thesis is in formalising Buddhist insights into logical expressions using Z notation. Although all states of mind in the framework arise in a user's perception of a system, formalised states of mind in the framework based on Z notation are still inadequate to cover all aspects of system states that might be expected from system formalists. While humans are completely different by nature, the attempt to describe states of mind in Buddhism in the same fashion as system is extreme and not desirable from a Buddhist perspective. Although a phenomenon and a perceiver of a phenomenon are always inconstant, explaining these preconditions and postconditions in system formalist manner is limited by Z notation (e.g., Can a system be perceived more than once? How is a perceived system stored in each state of mind? What happens to previous temporal states of a system?). As Bowen [**84**], a Z notation expert, stated, it is possible and desirable to "write non-deterministic specifications in Z" in which the exact execution of the specification cannot be determined, since the Z notation is designed to be expressive and understandable by humans rather than executable by computers. Formalising states of mind in Buddhism using Z notation limited to an existing system state and an updated system state is appropriate to our research focus.

8.4. Future Research

> Once the Blessed One was staying at Kosambi in the simsapa forest. Then, picking up a few simsapa leaves with his hand, he asked the monks, "What do you think, monks: Which are more numerous, the few simsapa leaves in my hand or those overhead in the simsapa forest?"
>
> "The leaves in the hand of the Blessed One are few in number, lord. Those overhead in the simsapa forest are more numerous."

> "In the same way, monks, those things that I have known with direct knowledge but have not taught are far more numerous [than what I have taught]. And why haven't I taught them? Because they are not connected with the goal, do not relate to the rudiments of the holy life, and do not lead to disenchantment, to dispassion, to cessation, to calm, to direct knowledge, to self-awakening, to Unbinding. That is why I have not taught them.", Simpasa Sutta [**40**].

The above quote may be appropriately illustrate that the Buddhist insights applied to systems engineering in this thesis are just a few leaves in comparison to the whole forest. The psychological constructs used in the Dhammic framework generated from states of mind in Buddhism are just a few conditions that were specifically chosen to describe how the condition of attachment is derived and how it underlies behavioural intentions and actions. There are a number of states of mind in Buddhism that have not been discussed in detail, but may provide contributions in cognitive informatics, which is a transdisciplinary approach to the cognitive and information sciences. In this thesis, the framework explains that the condition of attachment starts from *phassa* or the condition when a user and a system have contacted, *rupa* or the condition when the user perceives physical properties of the system, and *nama* or the condition when the user perceives quality of the system. In Buddhist philosophy, however, *phassa* or contact is classified into two main types [**274**, p.266]: 1) *panigha-samphassa* (impression by sensorial reaction) and 2) *adhivacana-samphassa* (mental impression). The classification of these two types of contact is based on *salayatanas* or six sense bases, i.e., eye and visible objects, ear and sound objects, nose and odor objects, tongue and taste objects, body and touch objects, and mind and mental objects. While the first type of contact is based on five sense bases that help humans identify, classify, and recognise a system, the second type of phassa is based on a mind sense base. There are also several conditions that have not been included in the framework, but may be useful in further applications and developments of the framework (e.g., *sankhara* (formations, fabrications), *vinnana* (consciousness), etc.).

While an intention construct is used in TAM as an indicator of system acceptance, *cetana* or intention is also acknowledged in Buddhism as an important condition strongly connected to human behaviours. However, the thesis has not discussed the connection between the intention construct and the action construct in detail. In Buddhism, human behaviours are classified into *kusala-kamma* (desirable action), which is recommended by Buddha, and *akusala-kamma* (undesirable action), which is not recommended by Buddha [**20**]. While desirable action is an action that does not offend others, undesirable action is an action that can offend others. This undesirable action is driven by *kilesa* (defilement), which is a condition situated in intention. This defilement condition is also further classified into three types of undesirable qualities, including lobha (greed), dosa (aversion), and moha (delusion). These three undesirable qualities are behind all other negative qualities that may offend others (e.g.,

greed, malevolence, anger, rancor, hypocrisy, arrogance, envy, miserliness, dishonesty, boastfulness, obstinacy, violence, pride, conceit, intoxication, and complacency). Understanding different types of these states of mind from a Buddhist perspective may also be useful for further improvements of the Dhammic framework that will help systems engineers to understand and predict potential behaviours arising from a particular intention.

The thesis has pointed out that the condition of attachment is behind system project failures. The thesis also illustrates how the condition of attachment can be effective to all individuals. In particular, the thesis focuses on the condition of attachment associated with users by explaining how a user perceives a system through a cluster of states of mind and how the condition of attachment can be the root cause of system project failures. The measurement results of DTAM has shown that the condition of attachment strongly influences behavioural intention of users to use Facebook. Although the experimental result has confirmed the hypothesis, further measurements of DTAM are still required in order to strengthen the validity of the results in the same way as TAM, in which its validity of psychological constructs has been empirically confirmed. As discussed in Chapter 6, Facebook may not be considered as an appropriate tool for testing DTAM measurements, as it may not be perceived by the users as an innovation or something new in which their willingness to adopt is observable. Further measurements of DTAM on different innovations may contribute to new results.

The thesis suggests the system engineer with the systems engineering path for avoiding attachment conflicts. The essence of understanding the condition of attachment may contribute to how a system should be designed in order to avoid attachment conflicts. However, this thesis did not investigate the condition of attachment associated with the systems engineer, who also perceives a system and designs a system in accordance with his or her own attached views. This thesis does not provide a rigorous view of what will happen if a system engineer's action becomes undesirable for users. Given that psychological constructs used in the Dhammic framework are applicable to all individuals, they are also applicable to analyse the condition of attachment associated with a system engineer. In this case, question items for psychological measurements on behavioural intentions of a system engineer may be constructed in accordance with the order of psychological constructs used in the Dhammic framework. The measurement results may be used to predict whether a system engineer is assertive or considerate. The results may also be used to identify whether a system engineer follows Buddhist MP systems engineering.

A layered reference model of the brain or LRMB was developed by Wang et al. [**353**] in order to formally and rigorously explain the functional mechanisms and cognitive processes (CPs) of natural intelligence. In LRMB, a comprehensive and coherent set of mental processes and their relationships is identified. In Wang et al. [**353**], 37 CPs are classified into six layers, i.e., sensation, memory, perception, action, metacognitive, and higher cognitive layers. These authors also mention that future extension and refinement of the CPs within the same hierarchical framework are also enabled in LRMB. There is a similarity between the nature

of the Dhammic framework and the LRMB framework. While the Dhammic framework provides an integrated framework for modeling the human mind from a Buddhist perspective, the LRMB reference model provides an integrated framework for modeling the brain and the mind from cognitive informatics. In this case, it may be useful in the further research to formally and logically explain how states of mind in Buddhism can map into perceptual conditions used in LRMB. Differences and similarities between perceptual conditions used in LRMB and those in the Dhammic framework can be compared. Psychological conditions used in the Dhammic framework may contribute to new CPs for LRMB from the comparative research.

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Appendices

Appendix A

Electronic Consent Form

THIS FORM WILL BE HELD FOR A PERIOD OF 6 YEARS

Project title: Investigating the influence of a condition of attachment in the actual usage of Facebook

Name(s) of Researcher(s): Pita Jarupunphol / Professor Clark Thomborson / Associate Professor Timothy Teo

I have read the Participant Information Sheet, have understood the nature of the research and why I have been selected. I have had the opportunity to ask questions and have them answered to my satisfaction.

- - I agree to take part in this research.
- - I understand that participation in this research project is voluntary.
- - I understand that I am free to withdraw participation at any time before the point of submitting the questionnaire.
- - I understand that I will not be able to withdraw any data provided by me after the point of submitting the questionnaire.
- - I understand that the online questionnaire will take approximately 20 minutes.
- - I understand that my responses will remain anonymous and any identifying information such as name, email address, and IP address will not be collected.
- - I understand the risks of losing data privacy when using an online questionnaire.
- - I understand that data will be stored and used for the PhD research of the student (Pita Jarupunphol) until the completion of the PhD research.

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For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag 92019, Auckland 1142. Telephone 09 373-7599 extn. 87830/83761. Email: humanethics@auckland.ac.nz.

Supervisors: Prof. Clark Thomborson (Department of Computer Science), Associate Professor Timothy Teo (School of Learning, Development, and Professional Practice)

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 24 March 2013 for (3) years, Reference Number 9087/2013

Click on the **"agree"** button below indicates that:

- You have read and understood the above information describing the aims and content of the following questionnaire, and
- You are aged 16 years or older, and
- You understand that, by submitting this questionnaire electronically you agree to take part in this research.

If you do not wish to participate in the research project, please decline participation by clicking on the **"disagree"** button.

Agree	
Disagree	

Section 1: Demographics

Please choose the right answer for each question below.

1) What is your age?	
Under 18 years	
18 to 24 years	
25 to 34 years	
35 to 44 years	
45 to 54 years	
55 to 64 years	
Age 65 or older	

2) What is your gender?	
Male	
Female	

3) How would you describe your current employment status?	
Employed full time	
Employed part time	
Unemployed / Looking for work	
Student	
Homemaker	
Retired	

4) What is your education level?	
Primary school	
Middle school	
High school	
Completed some college	
Bachelor's degree	
Completed some postgraduate	
Master's degree	
Doctoral degree, Ph.D.	
Other (Please Specify):	

5) What is your faculty?	
Science and Technology	
Management Science	
Education	
Humanities and Social Sciences	
Agricultural Technology	

6) What year are you in?	
1	
2	
3	
4	
Other (Please Specify):	

7) What is your major?	
Faculty of Science and Technology	
Applied Biology	
Chemistry	
Computer Science	
Environmental Science	
General Home Economics	
Home Economics	
Industrial Product Design	
Industrial Technology (Constructions)	
Industrial Technology (Manufacturing)	
Industrial Technology Management	
Information Technology	
Internet Technology	
Mathematics	
Physics	
Public Health	
Science	
Faculty of Education	
Business Education	
Computer Education	
Early Childhood Education	
Educational Technology and Innovations	
Fine Arts	
General Science	
Music Education	
Physical Education	
Social Studies	
Faculty of Humanities and Social Sciences	
Chinese Language for Communications	
Community Development	
Design Technology and Innovations	
English	
Information Science	
Law	
Library and Information Science	
Performing Arts	
Public Administration	
Thai Language for Communications	
Theatre and Dramatic Arts	
Faculty of Management Science	
Airline Business Management	
Business Administration (Accounting)	
Business Administration (Business Computing)	
Business Administration (Marketing)	
Communications	
Entrepreneurship Management	
Hotel Business Management	

Human Resource Management	
Marketing	
Meetings Incentives Conventions and Exhibitions (MICE) Management	
Tourism and Hospitality Management	
Tourism Industry	
Faculty of Agricultural Technology	
Agricultural Resource Management for Tourism	
Aquaculture	
Floral and Orchidales Management	
Food Science and Technology	

8) Please choose the right answer for each question item below.

	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neutral/Unable to judge	5 Somewhat Agree	6 Agree	7 Strongly Agree
1. I use the internet every day							
2. I use computers for many things in my daily life							
3. When I need to know something, I search the internet first							
4. I use the computer for leisure every day							
5. I keep in contact with my friends through the computer every day							
6. I am able to surf the internet and perform another activity comfortably							
7. I can check email and chat online at the same time							
8. When using the internet for my work, I am able to listen to music as well							
9. I am able to communicate with my friends and do my work at the same time							
10. I am able to use more than one applications on the computer at the same time							
11. I can chat on the phone with a friend and message another at the same time							
12. I use pictures more than words when I wish to explain something							
13. I use a lot of graphics and icons when I send messages							
14. I prefer to receive messages with graphics and icons							

15. I use pictures to express my feelings better							
16. I use smiley faces a lot in my messages							
17. I wish to be rewarded for everything I do							
18. I expect quick access to information when I need it							
19. When I send out an email, I expect a quick reply							
20. I expect the websites that I visit regularly to be constantly updated							
21. When I study, I prefer to learn those that I can use quickly first							

Section 2: Actual Usage of Facebook

Please choose the right answer for each question below.

9) Have you ever used Facebook?	
Yes	
No	

10) How long have you been using Facebook?	
Less than 1 month	
1 to 3 months	
4 to 6 months	
7 to 9 months	
10 to 12 months	
More than 12 months	
Other (Please Specify):	

11) On average per week, how often do you use Facebook?	
Never/Almost never	
About once a week	
A few times a week	
Several times a week	
Other (Please Specify):	

12) How frequently do you use Facebook:							
	1 Never	2 Rarely	3 Occasionally	4 Sometimes	5 Often	6 Very Frequently	7 All the time

13) How frequently do you use Facebook to:							
	1 Never	2 Rarely	3 Occasionally	4 Sometimes	5 Often	6 Very Frequently	7 All theTime
share images with friends							

communicate with friends							
play games with friends							
share opinions with friends							
search for new friends							
other purposes							

Section 3: Perceptions of Using Facebook

Please choose the best answer for each question.

14) Please choose the right answer for each question item below.							
	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neutral/Unable to judge	5 Somewhat Agree	6 Agree	7 Strongly Agree
1. Using Facebook is easy for me.							
2. I find it easy to use Facebook to connect with friends.							
3. It is easy for me to become skillful at using Facebook to connect with friends.							
4. Using Facebook is a flexible way for me to interact with my friends.							
5. My interaction with Facebook for connecting with friends is clear and understandable.							
6. Using Facebook is a good idea.							
7. Using Facebook is a wise idea.							
8. Using Facebook is favourable.							
9. Using Facebook is beneficial.							
10. I feel positive to use Facebook.							
11. Using Facebook enables me to connect with friends more quickly.							
12. Using Facebook improves my performance in connecting with friends.							
13. Using Facebook improves my productivity in connecting with friends.							
14. Using Facebook enhances my effectiveness in connecting with friends.							
15. Using Facebook makes it easier to connect with friends.							
16. Overall, I find using Facebook useful in							

connecting with friends.							
17. I am upset if I am not able to connect to Facebook.							
18. I find it easy to depend on Facebook to connect with friends.							
19. I am distressed if Facebook is discontinued.							
20. It is difficult to imagine life without Facebook.							
21. It helps to turn to Facebook when I want to connect with friends.							
22. I am annoyed if Facebook changes the way it looks.							
23. Facebook really understands me and my needs.							
24. It makes me uncomfortable if I cannot connect to Facebook.							
25. Overall, I feel comfortable have Facebook on my computer.							
26. I intend to use Facebook frequently to connect with friends in future.							
27. I intend to use Facebook on a regular basis to connect with friends in future.							
28. I intend to use Facebook as often as appropriate to connect with friends.							

15) Are there any barriers restricting you to use Facebook?

Appendix B

ชื่อโครงการ: ศึกษาค้นคว้าถึงปัจจัยที่มีผลกระทบต่อพฤติกรรมการใช้เฟซบุ๊คของนักศึกษามหาวิทยาลัยราชภัฏภูเก็ต

รายชื่อนักวิจัย: นายพิทา จารุพูนผล / ศาสตราจารย์ คล๊าก ทอมบอร์สัน / รองศาสตราจารย์ ทิโมที ทีโอ แห่งมหาวิทยาลัยโอ๊คแลนด์

ฉันได้อ่านข้อมูลสำหรับผู้เข้าร่วมเรียบร้อยแล้ว ซึ่งฉันได้เข้าใจถึงลักษณะและธรรมชาติของงานวิจัย รวมถึงสาเหตุที่ฉันได้เข้ามาร่วมในโครงการวิจัยนี้ ฉันมีโอกาสที่จะถามคำถามใดๆเพื่อที่จะให้คำตอบนั้นตรงตามความพึงพอใจของฉัน

- ฉันยินยอมที่จะเข้าร่วมในโครงการวิจัยนี้
- ฉันเข้าใจดีว่าการเข้าร่วมโครงการวิจัยนี้เป็นการสมัครใจของฉันเอง
- ฉันเข้าใจดีว่าฉันมีสิทธิที่จะถอนตัวออกจากการเข้าร่วมในโครงการวิจัยนี้ก่อนที่ฉันจะทำการตัดสินใจส่งแบบสอบถามนี้
- ฉันเข้าใจดีว่าฉันจะไม่สามารถเพิกถอนข้อมูลใดๆก็ตามของฉันหลังจากที่ฉันได้ทำการตัดสินใจส่งแบบสอบถามนี้
- ฉันเข้าใจดีว่าแบบสอบถามออนไลน์นี้จะใช้เวลาประมาณ 20 นาที
- ฉันเข้าใจดีว่าคำตอบของฉันจะคงไว้ในลักษณะของการไม่ประสงค์ออกนาม โดยข้อมูลส่วนตัวใดๆก็ตามที่อ้างอิงมาถึงฉันได้ เช่น ชื่อ อีเมล และ หมายเลขไอพีจะไม่มีการบันทึกเก็บเอาไว้
- ฉันเข้าใจถึงความเสี่ยงต่อการสูญเสียข้อมูลส่วนบุคคลเมื่อตอบแบบสอบถามออนไลน์นี้
- ฉันเข้าใจดีว่าข้อมูลจะถูกเก็บและใช้สำหรับงานวิจัยปริญญาเอกของนายพิทา จารุพูนผล จนกระทั่งงานวิจัยในระดับปริญญาเอกเสร็จสมบูรณ์

หากมีข้อสงสัยเกี่ยวกับโครงการวิจัย โปรดติดต่อ

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หากมีข้อสงสัยประการใดเกี่ยวกับด้านจริยธรรม ท่านสามารถติดต่อคณะกรรมการทางด้านจริยธรรมในการสรรหาผู้เข้าร่วมงานวิจัยได้ที่ The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag 92019, Auckland 1142. โทรศัพท์ 09 373-7599 ต่อ 87830/83761. อีเมล humanethics@auckland.ac.nz.

อนุมัติให้เก็บข้อมูลโดยคณะกรรมการทางด้านจริยธรรมในการสรรหาผู้เข้าร่วมงานวิจัย มหาวิทยาลัยโอ๊คแลนด์ ณ วันที่ 24 มีนาคม พ.ศ. 2556 สำหรับระยะเวลา (3) ปี หมายเลขอ้างอิงที่ 9087/2013

กรุณาคลิ๊กเลือกปุ่ม **ยินยอม** เพื่อเป็นการยืนยันว่า: 1. คุณได้อ่านและเข้าใจถึงข้อมูลที่อธิบายไว้ข้างบน ซึ่งอธิบายถึงวัตถุประสงค์และลักษณะเนื้อหาของแบบสอบถามที่จะตามมา 2. คุณอายุตั้งแต่ 16 ปีขึ้นไป 3. คุณเข้าใจดีว่าการคลิ๊กตอบแบบสอบถามออนไลน์นี้หมายความว่าคุณเห็นด้วยในการเข้าร่วมงานวิจัยโครงการนี้ ถ้าหากคุณไม่อยากเข้าร่วมโครงการวิจัยนี้ กรุณาเลือกปุ่ม **ไม่ยินยอม**	
ยินยอม	
ไม่ยินยอม	

ส่วนที่หนึ่ง: ข้อมูลพื้นฐานของผู้กรอกแบบสอบถาม (กรุณากากบาทในช่องว่างทางขวามือ)

1) อายุ	
ต่ำกว่า 18 ปี	
ระหว่าง 18 ถึง 24 ปี	
ระหว่าง 25 ถึง 34 ปี	
ระหว่าง 35 ถึง 44 ปี	
ระหว่าง 45 ถึง 54 ปี	
ระหว่าง 55 ถึง 64 ปี	
65 ปีขึ้นไป	

2) เพศ	
ชาย	
หญิง	

3) สถานะภาพการทำงาน	
ทำงานเต็มเวลา (Full-Time)	
ทำงานนอกเวลา (Part-Time)	
ว่างงาน / กำลังมองหางาน	
นักเรียน	
ทำงานบ้าน	

เกษียณอายุแล้ว	

4) ระดับการศึกษา	
ประถมศึกษา	
มัธยมศึกษาตอนต้น	
มัธยมศึกษาตอนปลาย	
สายอาชีพ	
ปริญญาตรี	
ปริญญาโท	
ปริญญาเอก	
อื่นๆ (กรุณาอธิบาย)	

5) คณะ	สาขา **(โปรดระบุสาขาที่ท่านกำลังศึกษา)**	กำลังศึกษาอยู่ชั้นปีที่	
วิทยาศาสตร์และเทคโนโลยี		ปีที่ 1	
ครุศาสตร์		ปีที่ 2	
มนุษย์ศาสตร์และสังคมศาสตร์		ปีที่ 3	
วิทยาการจัดการ		ปีที่ 4	
เทคโนโลยีการเกษตร		อื่นๆ	

6) : กรุณากากบาทเลือกคำตอบที่**ตรงตามความรู้สึกของคุณ**เพียงคำตอบเดียวในแต่ละหัวข้อย่อย

	1.ไม่เห็นด้วยอย่างยิง	2.ไม่เห็นด้วย	3.ค่อนข้างไม่เห็นด้วย	4.เฉยๆ/ไม่สามารถระบุได้	5.ค่อนข้างเห็นด้วย	6.เห็นด้วย	7.เห็นด้วยอย่างยิ่ง
1. ฉันใช้อินเตอร์เน็ตทุกๆวัน							
2. ฉันใช้คอมพิวเตอร์เพื่อทำหลายสิ่งในชีวิตประจำวัน							
3. เวลาที่ฉันอยากรู้อะไร ฉันค้นจากอินเตอร์เน็ตเป็นอันดับแรก							
4. ฉันใช้คอมพิวเตอร์เวลาที่ฉันมีเวลาว่างทุกๆวัน							
5.ฉันติดต่อกับเพื่อนผ่านคอมพิวเตอร์ทุกๆวัน							

6. ฉันสามารถใช้อินเตอร์เน็ตและทำงานอื่นๆด้วยอย่างสะดวกสบาย							
7. ฉันสามารถตรวจอีเมลและแชตกับเพื่อนได้ในเวลาเดียวกัน							
8. เวลาที่ฉันใช้อินเตอร์เน็ตในการทำงาน ฉันสามารถฟังเพลงได้ด้วยในขณะเดียวกัน							
9. ฉันสามารถสื่อสารกับเพื่อนและทำงานของฉันได้ในเวลาเดียวกัน							
	1.ไม่เห็นด้วยอย่างยิ่ง	2.ไม่เห็นด้วย	3.ค่อนข้างไม่เห็นด้วย	4.เฉยๆ/ไม่สามารถระบุได้	5.ค่อนข้างเห็นด้วย	6.เห็นด้วย	7.เห็นด้วยอย่างยิ่ง
10. ฉันสามารถใช้งานมากกว่าหนึ่งโปรแกรมบนคอมพิวเตอร์ได้ในเวลาเดียวกัน							
11.ฉันสามารถแชตกับเพื่อนทางโทรศัพท์และส่งข้อความไปให้เพื่อนอีกคนได้ในเวลาเดียวกัน							
12. ฉันใช้ภาพมากกว่าคำพูดในการที่ฉันต้องการอธิบาย							
13. ฉันใช้กราฟฟิกส์และไอคอนมากมายในการส่งข้อความ							
14. ฉันเลือกที่จะรับข้อความที่มีกราฟฟิกส์และไอคอน							
15. ฉันใช้ภาพในการแสดงออกถึงความรู้สึกได้ดีกว่าข้อความ							
16. ฉันใช้ตัวไอคอนยิ้มบ่อยมากในการส่งข้อความ							
17. ฉันหวังว่าจะได้รับรางวัลหรือผลตอบแทนสำหรับทุกสิ่งที่ได้ทำไป							
18. ฉันมีความคาดหวังในการเข้าถึงข้อมูลอย่างรวดเร็วเมื่อใดก็ตามที่ฉันต้องการ							
19. เมื่อใดก็ตามที่ฉันส่งอีเมล ฉันหวังว่าจะได้รับการตอบกลับอย่างรวดเร็ว							
20. ฉันหวังว่าเว็บไซต์ที่ฉันเข้าชมอยู่							

เสมอจะมีการอัพเดตข้อมูลอย่างต่อเนื่องสม่ำเสมอ							
21. เมื่อใดก็ตามที่ฉันต้องศึกษาเรียนรู้ ฉันเลือกที่จะเรียนรู้ในสิ่งที่ฉันสามารถใช้งานได้อย่างรวดเร็วเป็นอันดับแรก							

ส่วนที่ 2: พฤติกรรมการใช้งานเฟซบุ๊ค

7) คุณเคยใช้เฟซบุ๊คหรือไม่	
เคย	
ไม่เคย	

8) คุณใช้เฟซบุ๊คมานานเท่าไร	
น้อยกว่า 1 เดือน	
1 ถึง 3 เดือน	
4 ถึง 6 เดือน	
7 ถึง 9 เดือน	
10 ถึง 12 เดือน	
มากกว่า 12 เดือน	
อื่นๆ (โปรดระบุ):	

11) โดยเฉลี่ยในแต่ละสัปดาห์ คุณใช้เฟซบุ๊คบ่อยแค่ไหน	
ไม่เคย/เกือบจะไม่เคย	
ประมาณ 1 ครั้งต่อสัปดาห์	
ไม่กี่ครั้งต่อสัปดาห์	
หลายครั้งต่อสัปดาห์	
อื่นๆ (โปรดระบุ):	

12) โดยรวมคุณใช้เฟซบุ๊คบ่อยแค่ไหน							
	1.ไม่เคย	2.เกือบไม่เคย	3.น้อยครั้ง	4.บางครั้ง	5.บ่อย	6.บ่อยมาก	7.ตลอดเวลา

13) บ่อยแค่ไหนที่คุณใช้เฟซบุ๊คสำหรับ:							
	1.ไม่เคย	2.เกือบไม่เคย	3.น้อยครั้ง	4.บางครั้ง	5.บ่อย	6.บ่อยมาก	7.ตลอดเวลา
แลกเปลี่ยนภาพกับเพื่อน							
สื่อสารกับเพื่อน							
เล่นเกมส์กับเพื่อน							
แลกเปลี่ยนความคิดเห็นกับเพื่อน							
หาเพื่อนใหม่							
วัตถุประสงค์อื่น							

ส่วนที่ 3: สภาวะการรับรู้ต่อการใช้เฟซบุ๊ค

14) : กรุณากากบาทเลือกคำตอบที่**ตรงตามความรู้สึกของคุณ**เพียงคำตอบเดียวในแต่ละหัวข้อย่อย							
	1.ไม่เห็นด้วยอย่างยิง	2.ไม่เห็นด้วย	3.ค่อนข้างไม่เห็นด้วย	4.เฉยๆ/ไม่สามารถระบุได้	5.ค่อนข้างเห็นด้วย	6.เห็นด้วย	7.เห็นด้วยอย่างยิ่ง
1. การใช้เฟซบุ๊คนั้นง่ายสำหรับฉัน							
2. ฉันพบว่ามันช่างง่ายเหลือเกินในการใช้เฟซบุ๊คติดต่อกับเพื่อน							
3. มันช่างง่ายในการที่ฉันจะชำนาญในการใช้เฟซบุ๊คติดต่อกับเพื่อน							
4. การใช้เฟซบุ๊คนั้นเป็นอีกหนทางที่ยืดหยุ่นสำหรับฉันในการติดต่อกับเพื่อน							
5. การใช้เฟซบุ๊คในการติดต่อกับเพื่อนนั้นชัดเจนและเข้าใจง่าย							
6. การใช้เฟซบุ๊คนั้นเป็นความคิดที่ดี							
7. การใช้เฟซบุ๊คนั้นเป็นความคิดที่ฉลาด							
8. การใช้เฟซบุ๊คนั้นเป็นที่โปรดปราน							

9. การใช้เฟซบุ๊คนั้นเป็นประโยชน์							
10. ฉันรู้สึกในแง่บวกต่อการใช้เฟซบุ๊ค							
11. การใช้เฟซบุ๊คทำให้ฉันสามารถติดต่อกับเพื่อนได้เร็วขึ้น							
	1.ไม่เห็นด้วยอย่างยิง	2.ไม่เห็นด้วย	3.ค่อนข้างไม่เห็นด้วย	4.เฉยๆ/ไม่สามารถระบุได้	5.ค่อนข้างเห็นด้วย	6.เห็นด้วย	7.เห็นด้วยอย่างยิ่ง
12. การใช้เฟซบุ๊คนั้นเพิ่มศักยภาพของฉันในการติดต่อกับเพื่อน							
13. การใช้เฟซบุ๊คทำให้ฉันติดต่อกับเพื่อนได้มากขึ้น							
14. การใช้เฟซบุ๊คนั้นเพิ่มประสิทธิภาพในการติดต่อกับเพื่อน							
15. การใช้เฟซบุ๊คทำให้ฉันติดต่อกับเพื่อนได้ง่ายขึ้น							
16. โดยรวมแล้ว ฉันพบว่าการใช้เฟซบุ๊คนั้นมีประโยชน์สำหรับติดต่อกับเพื่อน							
17. ฉันรู้สึกผิดหวังถ้าหากฉันไม่สามารถเข้าเฟซบุ๊คได้							
18. มันง่ายเหลือเกินที่ฉันจะเลือกใช้เฟซบุ๊คในการติดต่อกับเพื่อน							
19. ฉันรู้สึกอึดอัดและผิดหวังถ้าหากเฟซบุ๊คถูกยกเลิก							
20. มันเป็นอะไรที่ค่อนข้างยากถ้าหากชีวิตฉันต้องขาดเฟซบุ๊ค							
21. ฉันเลือกใช้เฟซบุ๊คเมื่อใดก็ตามที่ฉันต้องการติดต่อกับเพื่อน							
22. ฉันรู้สึกขุ่นมัวถ้าหากเฟซบุ๊คมีการปรับเปลี่ยนรูปและลักษณะในการใช้งาน							
23. เฟซบุ๊คเข้าใจความต้องการของฉันจริงๆ							
24. มันทำให้ฉันรู้สึกไม่สบายใจถ้าหากฉันไม่สามารถเข้าใช้เฟซบุ๊คได้							
25. โดยรวมแล้ว ฉันรู้สึกสบายใจที่จะมีเฟซบุ๊คอยู่บนคอมพิวเตอร์ของฉัน							

26. ในอนาคต ฉันตั้งใจจะใช้เฟซบุ๊คบ่อยครั้งในการติดต่อกับเพื่อน							
	1.ไม่เห็นด้วยอย่างยิง	2.ไม่เห็นด้วย	3.ค่อนข้างไม่เห็นด้วย	4.เฉยๆ/ไม่สามารถระบุได้	5.ค่อนข้างเห็นด้วย	6.เห็นด้วย	7.เห็นด้วยอย่างยิ่ง
27. ในอนาคต ฉันตั้งใจจะใช้เฟซบุ๊คในกิจวัตรประจำวันสำหรับการติดต่อกับเพื่อน							
28. ในอนาคต ฉันตั้งใจจะใช้เฟซบุ๊คบ่อยตามความเหมาะสมในการติดต่อกับเพื่อน							

15) มีอุปสรรคใดบ้างในการใช้เฟซบุ๊ค (หากมี กรุณาอธิบายในช่องว่างข้างล่าง)

Appendix C

Help me prove the insight of Buddhism is considerable in computer science!

My name is Pita Jarupunphol. I am a PhD student in computer science at the University of Auckland, New Zealand under the supervision of Professor Clark Thomborson. I am also a lecturer in informatics at Phuket Rajabhat University.

What am I doing?

I am investigating the influence of **upadana (a condition of attachment)**, which an insight of Buddhism, in the actual usage of Facebook.

What are benefits of being part of this investigation?

You are making merits in:

- helping me measure psychological conditions associated with behavioural usage of a system;
- helping me prove that a condition of attachment from Buddhist perspective can be considerable for predicting a user's behavioural usage of a system; and
- helping a system engineer to be mindful that a user's attachment condition influences success and failures of a system project and should not be ignored.

Want to be part of this merit-making activity?

Contact: Pita Jarupunphol, **pjar019@aucklanduni.ac.nz**

https://sites.google.com/site/pitajarupunphol/experiments

You will be asked to answer a questionnaire about your actual usage and perceptions of Facebook.The questionnaire will take approximately 20 minutes.

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 24 March 2013 for (3) years, Reference Number 9087/2013

Appendix D

ช่วยพิสูจน์ว่ามุมองจากศาสนาพุทธนั้นเป็นจริงในวิทยาการคอมพิวเตอร์

อาจารย์พิทา จารุพูนผล เป็นนักศึกษาปริญญาเอกทางด้านวิทยาการคอมพิวเตอร์ที่มหาวิทยาลัยโอ๊คแลนด์ภายใต้การให้คำปรึกษาของศาสตราจารย์คล๊าก ทอมบอร์สัน ซึ่งกำลังอยู่ในช่วงพิสูจน์สมมติฐานขั้นตอนสุดท้าย

อาจารย์เขากำลังพิสูจน์อะไรอยู่ล่ะ

เขากำลังศึกษาค้นคว้าถึงผลกระทบของสภาวะยึดมั่นถือมั่นทางจิตวิทยาหรือที่เรียกว่าอุปปาทานทางพุทธศาสนาที่มีต่อพฤติกรรมการใช้เฟซบุ๊ค

ประโยชน์ที่จะได้รับจากการศึกษาวิจัยครั้งนี้

คุณกำลังช่วยทำความดีดังต่อไปนี้

- ช่วยในการวัดเงื่อนไขทางจิตวิทยาที่เกี่ยวข้องกับพฤติกรรมการใช้ระบบ
- ช่วยพิสูจน์ว่าอุปปาทานที่เป็นเงื่อนไขทางจิตที่ยึดมั่นถือมั่นในพุทธศาสตร์สามารถนำมาใช้พิจารษรในการคาดคะเนพฤติกรรมการใช้ระบบของผู้ใช้
- ช่วยให้นักวิศวกรรมระบบตระหนักว่าเงื่อนไขยึดมั่นถือมั่นทางจิตนั้นมีผลต่อความสำเร็จหรือล้มเหลวต่อโครงการพัฒนาระบบและไม่ควรถูกเพิกเฉยหรือไม่ให้ความสำคัญ

ใครที่จะร่วมทำความดีครั้งนี้บ้างเอ่ย

ติดต่อ: นายพิทา จารุพูนผล, pjar019@aucklanduni.ac.nz หรือไปที่ลิงค์โดยตรงได้ที่

https://sites.google.com/site/pitajarupunphol/experiments

คุณจะต้องตอบคำถามเกี่ยวกับพฤติกรรมการใช้เฟซบุ๊คของคุณ โดยแบบสอบถามจะใช้เวลาโดยรวมประมาณ 20 นาที

อนุมัติให้เก็บข้อมูลโดยคณะกรรมการทางด้านจริยธรรมในการสรรหาผู้เข้าร่วมงานวิจัย มหาวิทยาลัยโอ๊คแลนด์ ณ วันที่ 24 มีนาคม พ.ศ. 2556 สำหรับระยะเวลา (3) ปี หมายเลขอ้างอิงที่ 9087/2013

Appendix G

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

Department of Computer Science
The University of Auckland
Private Bag 92019
Auckland, New Zealand
Phone: +64 9 373 7599 ext 85857

PARTICIPANT INFORMATION SHEET

Project title: Investigating the influence of a condition of attachment in the actual usage of Facebook

Researchers: Pita Jarupunphol / Professor Timothy Teo / Professor Clark Thomborson

To: The Participant

This research project is being undertaken by Pita Jarupunphol, a PhD student in Computer Science. This research is a part of a PhD degree at the Department of Computer Science, University of Auckland. The purpose of this research is to study the influence of a condition of attachment, which is an insight from Buddhism, on users' behavioural intention toward using Facebook. Anyone who is a tertiary student is invited to participate in this research.

Our research involves the use of an online questionnaire, which will take approximately 20 minutes to complete. The study will consist of the following parts.

- **Part 1. Demographics (5 minutes):** In this section, participants will be asked a few general questions about their demographic information (e.g., age, gender, employment status, etc.).
- **Part 2. Users' actual usage of Facebook (5 minutes):** In this section, participants will be asked to answer questions about their actual usage of Facebook (e.g., how long have they used Facebook, how frequently do they use Facebook, etc.).
- **Part 3. Users' perceptions of Facebook (10 minutes):** In this section, participants are asked to answer different sets of questions about their perceptions of Facebook in accordance with TAM constructs with a condition of attachment included (e.g., perceived ease of use, perceived usefulness, attitude toward using, attachment toward using, and behavioural intention toward using.).

The data that you provide will be used for the PhD research of the student (Pita Jarupunphol). Data will also be used to report findings of this research in conference papers and journal articles. Findings of this research will be reported in the student's PhD thesis. Any identifying information such as your name and IP address will not be recorded in the data. All information that you provide in the questionnaire will remain anonymous. Data will not be made publicly available on the Internet. They will only be available to the researchers of this research project, and will be stored securely in electronic devices within the university premises for a period of six years. After that period, the information will be destroyed from all devices in a secure manner.

Participation in this study is completely voluntary. If you decide to participate in this research, you have the right to withdraw from participation at any time before the point of submitting the questionnaire. However, you are unable to withdraw data provided by you

from the research after the point of submitting the questionnaire. This is because the data will not contain any information that will be identified as belonging to any particular participants. The information that you provide will be analysed and reported anonymously.

If you are willing to participate, please complete the online questionnaire at the link provided in the email. You will not be asked to sign a consent form. However, there will be an electronic consent at the beginning of the online questionnaire. Please note that by submitting the online questionnaire indicates that you agree to take part in this research.

A summary of the research findings will be made available online at https://sites.google.com/site/pitajarupunphol/results after the completion of this research project. If you have any questions about the research, please contact us. Contact details are provided below.

Contacts

Professor Gill Dobbie (Head of Department, Department of Computer Science)
Phone: +64 9 373 7599 ext 83949
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Professor Clark Thomborson (Supervisor, Department of Computer Science)
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Professor Timothy Teo (Supervisor, School of Learning, Development and Professional Practice)
Phone: +64 9 623 8899 ext 48542
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Pita Jarupunphol (PhD student, Department of Computer Science; and Lecturer, Phuket Rajabhat University)
Phone: +64 21 026 27094 (New Zealand), +66 76 211 959 ext 414 (Thailand)
Email: pjar019@aucklanduni.ac.nz

For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag 92019, Auckland 1142. Telephone 09 373-7599 extn. 87830/83761. Email: humanethics@auckland.ac.nz.

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON **24 March 2013** for (3) years, Reference Number **9087/2013**

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