

A Framework for the Study of Modelling Techniques in Agile Methods

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Since the software crisis of the 1960's, numerous methodologies have been developed to impose a disciplined process upon software development, and to encourage logical, rational and systematic thought. However, the failure of heavyweight methods has given rise to a new breed of methodology known as the agile method. Although many in industry and academia have heralded agile methods as revolutionary, little academic research has been carried out to study how these methods will facilitate logical programming and, indeed, logical thought. This paper looks at the extensive literature on flexibility in an attempt to provide a conceptual foundation upon which a study of model engineering in agile methods can be conducted. The review examines literature from such disciplines as management, labour, manufacturing and marketing theory and discovers that there is no consensus as to what flexibility entails, only that it is not a single entity or ability but rather a broad concept of many dimensions that is drawn from many sources. As a result, this paper proposes that a study of the impact that agile approaches will have on modelling techniques will have to consider many factors.

1. Introduction

Early software development approaches in the 1960s were highly ad hoc and unstructured, largely due to the fact that technology could only achieve simple goals and therefore software development was not a complex task. However, as technology became more advanced, simple approaches to development resulted in programs of the era being described as “conglomerations of idiosyncrasies” Dijkstra (1972). Bugs became more prevalent and increasingly difficult to fix, resulting in the need for more logical approaches to programming, instead of the hacking that was the standard approach at the time. The failure of ad hoc approaches to traditional systems development have resulted in over 30 years of trial and error research into development tools, models and techniques. The results of such research include the development of formalized development methodologies. A methodology can facilitate a systematic and rational approach to be taken to systems development (Floyd, 1987), and embraces scientific, logical thought, an orientation regarded as the very paradigm of what it means to think and be intelligent (McPhee, 1997).

However, it is now evident that, although these formal methodologies may encourage logical thinking and programming, they are not the silver bullet that developers are looking for. Firstly, empirical research shows that methodology use in practice is rather limited (Fitzgerald, 1998), and those developers who do use methodologies tend to use different combinations and parts of methodologies rather than following all the steps required by a particular methodology (Hidding, 1996; Fitzgerald, 1996). Research has also indicate that methodologies are not universally applicable (Benyon & Skidmore, 1987), are too beauraucratic (Fowler, 2000), are unable to handle people factors (Boehm, 1981; Brooks, 1987; Glass, 1991), and lead to “goal displacement (Fitzgerald, 1994)

Many authors assert that current software development practice is more reminiscent of that of software development in the 1960's. There is a reliance on *ad hoc* trial-and-error methods, applications are handcrafted, development processes are poorly understood, and there is a tendency to bypass analysis and design and proceed directly to implementation. This trend is exacerbated by the emergence of new and more complex technologies such as Web systems and hypermedia (Lowe & Hall, 1999; Murugesan et al, 1999; Coda et al, 1998; Powell et al, 1998; Enguix & Davis, 1999; Bernstein et al, 1992). As a result of this shift, agile methods have appeared. These methods advocate a return toward less formal approaches to software development. Agile methods such as XP and Scrum are still evolving and it is only recently that academic research has focused on this area. This paper attempts to build a conceptual foundation for the study of agile methods.

2. Literature on Agile Methods

The term "agile" means quick-moving, nimble and active. Unfortunately, it is much more difficult to find such a precise and concise definition of an agile method. There are numerous ambiguous definitions such as "'a collection of philosophies that will enable IT professionals to work together effectively" (Ambler, 2002a). Such methods have been described as "young, fast-moving players" (Constantine, 2001), that "compromise between no process and too much process" (Fowler & Highsmith, 2001) and "that are flexible enough to smoothly adapt to changes in requirements and delivery schedules" (Aoyama, 1998; Jacobson, 2002). They "mirror today's turbulent business and technology environment" (Highsmith & Cockburn, 2001) and are inherently "adaptive rather than predictive" (Fowler, 2000). They "dispense with all but the essentials" (Boehm, 2002), do "not do anything that is a waste of time" (Highsmith, 2002), and "call for keeping code simple, testing often, and delivering small, functional bits of the application" (Copeland, 2001)

In contrast, such broad interpretations of what constitutes an agile method are negated by Cockburn (2002), who implies that the meaning of an agile method is very narrow in scope, by suggesting that alternatives to agile development arise "as soon as the development team focus their attention on rigorous, predictable, repeatable, defect-free, traceable or even fun software development". Cockburn (2002) even dismisses the existence of an agile method altogether, claiming that it is something that developers can only aspire to, and only hindsight can determine whether an agile method was actually adhered to.

As there is no concrete definition of an agile method, the most accurate assessment of their construct are laid out in the Agile Manifesto (Fowler & Highsmith, 2001):

- *Satisfy the customer through early and continuous delivery of valuable software:* This principle moves away from the traditional view that "achieving a plan equals project success equals added customer value" (Fowler & Highsmith, 2001). Instead there is a realisation that "customers don't care about a Gantt chart or documents. "They care about seeing some piece of business functionality that proves that the evolving application is serving their business needs" (Highsmith, 2002).
- *Sustainable development is promoted, facilitating indefinite development:* Software development projects today have a tendency to involve long nights and weekends, correcting the mistakes of unresponsive planning (Beck & Fowler, 2001; Martin, 2001). The agile movement is dependant on the alertness and creativity of the development team, and such excessive hours are counter-productive on a long-term project (Fowler & Highsmith, 2001).
- *Simplicity is essential:* Ambler (2002a) defines simplicity in relation to the agile movement as "maximising the amount of work not done". "Never do anything that is a waste of time- and be prepared to wage long- tedious wars over this principle" (Highsmith, 2002).

- *Welcome changing requirements, even late in development:* Changing requirements are embraced by agile methods, but structured techniques must be used, Refactoring is a techniques central to this embrace, allowing small code changes while retaining original semantics and still keeping code simple (Fowler, 1999), allowing the development team to “cut the fat and help keep the code keep fit” without losing functionality (Ambler, 2002b)
- *Deliver working software frequently:* Customers want to see a working product regularly, but it is important to realise that “deliver” is not the same as “release”. Internal demonstrations are just as useful as a full-scale release into production, which may have adverse effects and may not be practical over a short period of time (Fowler & Highsmith, 2001).
- *Working software is the primary measure of progress:* Ambler (2002a) indicates that the debate between agile and heavyweight methods concerns “software development not documentation development”.
- *Continuous attention to technical excellence:* Although agile development is somewhat similar to the “quick and dirty” RAD efforts of the last decade, in terms of speed and flexibility, there is a big difference in terms of technical cleanliness. Design quality is essential to maintaining agility (Fowler & Highsmith, 2001).
- *Business people and developers must work together daily:* Only the customer can say what they want, but they do not have the skills to specify the system. A contract is necessary to formally state everybody’s role and responsibility. However, “a contract is not a substitute for communication” (Ambler, 2002a).
- *Face-to-face communication is the best method of conveying information:* Tacit knowledge can be transferred by moving the people who have that knowledge around. Tacit knowledge cannot be transferred by documentation, because tacit knowledge contains “not only the facts but also the relationship among the facts and how those facts can be applied to a specific situation” (Dixon, 2000).
- *The team regularly reflects on how to become more productive and efficient:* Agile methods, by their inherent nature, are not something to be picked and followed slavishly. Agile methods welcome change, but being able to handle change is irrelevant if these changes are not realised.
- *The best work emerges from self-organising teams:* “Lightweight means accepting that we can’t identify and control every little task” (Highsmith, 2002).
- *Build projects around motivated individuals:* This principle illustrates the fact that the Agile Alliance value “individuals and interactions over processes and tools”. Ambler (2002a) compares the productivity of a group of strong programmers without tools to that of a group of “burger flippers” with a well-defined process and sophisticated tools. He highlights the fact that processes and tools are still important, but just that “a fool with a tool is still a fool”.

In order to study the facility for logic computation and development in agile methods, it would be necessary to study the effect of applying each of the principles listed above. However, it would be insufficient to do so. Firstly, there are many agile methods such as XP (Beck, 1999), and no two agile methods are the same. In fact they are often radically different from each other and none adhere completely to the 12 principles listed above. Secondly, most of the principles are somewhat vague and the techniques used to adhere to these principles can vary wildly. For example the principle of simplicity may be ideal in theory, but one individual’s interpretation of simplicity may differ from another. Therefore, in order to construct a comprehensive framework on which to study agile methods, it is necessary to look deeper than the twelve principles on which these methods are based. The rest of this paper looks at the concept of agility and flexibility and reviews the comprehensive literature on the subject.

3. Literature on Flexibility

3.1. Definition of Flexibility

The World Book Dictionary defines the adjective *flexible* as being “easily adapted to fit various conditions”. However, other definitions extend this simplistic version and often introduce new terms that require definition themselves (Table 1). For example, Webster’s dictionary believes that flexibility is “characterised by a ready capability for modification or change, by plasticity, pliancy, variability and often by consequent adaptability to new situations”.

Table 1: Terms Associated With Flexibility

Term	Description
Adaptability	Regarded as the ability to respond to <i>foreseen</i> changes (Eppink, 1978; Evans, 1982), whereas the regular definition of flexibility lends itself to the ability to respond to <i>unforeseen</i> changes
Elasticity	Interpreted as being similar to adaptability, but is more focused on the ability to <i>return to a normal state</i> following a response to change
Liquidity	Refers to the <i>ease with which an entity can make a transition</i> from one period to a desired position in another period (Jones & Ostroy, 1975).
Plasticity	Regarded as the ability to maintain a state, but more accurately in terms of flexibility, the ability to <i>maintain that state while transitioning to another</i> .
Robustness	Interpreted as the ability to <i>endure</i> all transitions caused by <i>foreseen</i> changes.
Resilience	Resilience is similar to Robustness but focuses on <i>unforeseen</i> changes. In this instance the term ability to <i>endure</i> would be replaced by the term <i>ability to absorb</i> or <i>ability to</i> .

3.2. Context of Flexibility

The previous section highlights the adversity researchers have faced in attempting to reach a comprehensive definition of flexibility. However, a review of the use of the term across disciplines does nothing but highlight this adversity even further. An analysis of the literature within disciplines such as manufacturing, marketing and human resources, illustrates that, not only are there inconsistencies of the use of the term across disciplines, but also between academics within the same field.

- *Manufacturing flexibility*: It has been defined as a strategy aimed at the maximisation of product differentiation (Parthasarthy & Sethi, 1993). Abernethy & Lillis (1995) define the term as an organisation’s ability to respond to changes in demand by switching production of one product to another. Kulatilaka’s (1993) interpretation is how a business can choose between different types of manufacturing machine. Hutchinson & Sinha (1989) refer to the ability to vary production volume instantaneously. Manufacturing flexibility research also attempts to deconstruct the term into more specific definitions such as *product mix flexibility*. However, adopting a narrower focus is still unable to achieve a consensus. Slack (1983) defines the term as “the ability to manufacture a particular mix of products within a minimum

planning period, Gerwin (1982) defines it as “the ability to manufacture a mix of products simultaneously”, while (Abernethy & Lillis, 1995) adds a third variant, defining it as “the ability to switch from the production of one product to the production of another”.

- *Labour Flexibility*: The study of human resources is a prime example of the diverse nature in which the term flexibility is used. *Functional flexibility* refers to the ability of an organisation to deploy and redeploy employees between different roles, tasks and activities (Atkinson, 1985). *Flexible specialisation* on the other hand refers to how easily a specialised job can be adapted by other users or technology to suit a fragmented, volatile market (Blair, 1999). *Numerical flexibility* allows the number of resources or the number of hours that they work to be changed in line with demand for those resources or their work (Atkinson, 1985), while *Flexi-time* (Ullrich, 1980) allows users to set the hours that they will work to suit their own preferences. *Financial flexibility* refers to an organisation’s ability to manipulate labour costs in line with external labour market forces (Atkinson, 1985). Atkinson (1989) then examines flexibility from the viewpoint of the employees, referring to the ease with which they can move around the organisation as *enhanced mobility*.
- *Finance Flexibility*: Donaldson (1971) refers to this term as the optimisation of the mix between debt and equity financing in order to minimise cost and maximise wealth at a particular point in time. Bernstein (1978) interprets this phenomenon as *financing flexibility*, and defines it as the ability to raise funds, particularly in adverse capital markets. The FASB (1984) use the term *financial flexibility* in reference to the balancing of cash flows, instead of debt or equity financing. According to their interpretation, the term refers to the ability to change the amounts and timing of cash flows in and out of the organisation. Heath (1978) also thinks the term applies to cash flows. However, his interpretation is more specific, suggesting that it is the ability to “take corrective action to eliminate any excess cash payments over receipts. *Financial mobility* however, refers not an organisation’s ability to access financial resources or to vary cash flows, but to an organisation’s ability to redirect the use of those resources in response to new information (Donaldson, 1971).
- *Marketing Flexibility*: Within the field of marketing, flexibility is recognised as a critical talent to possess. It refers to the ability of an organisation to reposition itself in markets and to dramatically shift patterns of customer choice in established markets (Prahalad & Hamel, 1990). It also refers to the ability to dismantle current marketing strategies and change the “advertising game plan” (Harrigan, 1985). It also refers to barriers to entry and exit of markets, which may restrict the impact of a marketing strategy (Harrigan, 1985).
- *Management Theory*: The majority of researchers fail to accept such a generic definition (Aaker & Mascarenhas, 1984; Adler, 1988; De Leeuw & Volberda, 1996; Eppink, 1978; Evans, 1991; Gerwin, 1993; Suarez, Cusanmano & Fine, 1995; Wiseman, 1985) due to the multidimensional, polymorphous nature of flexibility.

3.3. Sources of Flexibility

Many researchers have shown that flexibility is not a capability possessed by an entity itself, but rather a capability of the components of that entity:

- *People*: Correa (1994) believes that “an organisation is as flexible as its people”. A workforce needs to be multiskilled to facilitate interchangeability. They need to be able to work in teams (Kohler, 1989; Womack et al, 1990), and intra- and inter-team communication must be facilitated (Kohler, 1989).
- *Technology*: The use of flexible technology enables the organisation to respond to change. Pasmore refers to the previous point, warning that flexible technology is useless unless the people using it are also flexible.

- *Work*: Work flexibility refers to the ability to create flexibility through collaboration and teams. In such an environment, job descriptions are flexible and cross-functional involvement is facilitated. There is again a reference to the people factor, as encouraging resources to swap between roles and teams is irrelevant if the people are not trained in the various skills required.
- *Thinking*: Examples of flexible thinking referred to by Pasmore include the encouragement of innovation, experimentation and research and development, which is achieved through the sharing of knowledge, freedom of movement and an overall organisational structure which encourages, supports and rewards learning.
- *Managers*: The fifth source acknowledges the fact that in order to have a flexible environment, flexibility must be encouraged from the top down. However, the ability of a manager to embrace flexibility is restricted to the resources that the manager controls, adding further emphasis to the necessity of individual people flexibility.
- *Organisational design*: This source refers to the overall structure that controls the previous sources. For example the ability of an organisation to reorganise training and team structures etc.

3.4. Components of Flexibility

Often research identifies flexibility as the ability to adapt to change or the ability to be nimble. However, flexibility is a much more complex entity than this and is made up of a number of components and sub-divisions:

- *Temporal*: Golden & Powell (2000) describe the temporal dimension of flexibility as the “length of time it takes for an organisation to respond to environmental change” or to “adapt within a given time frame”. Furthermore, as change may arise due to environmental influences the temporal dimension must incorporate the length of time taken for an entity to recognise that change has occurred, to decide on what action to take, and to carry out that action. Volberda’s (1998) framework compares time taken to adapt to change against the variety of that change, acknowledging the fact that rapid response to familiar change is not necessarily better than a slow response to large, strategic change.
- *Foreseen v. Unforeseen Change*: The literature on flexibility has made a distinction between the ability to be flexible in response to foreseen change and unforeseen change. Foreseen change is essentially risk, where all outcomes are known but the probability of each outcome occurring is not, and uncertainty where the various outcomes cannot be identified or measured with accuracy.
- *Internal v External Flexibility*: This dimension of flexibility is defined as “the area in which the flexibility is created” (Golden & Powell, 2000). Goudswaard & de Nanteuil (2000) illustrate this concept through labour flexibility referring to internal flexibility as the ability of an organisation to vary employee’s duties, working hours or salaries, while external flexibility refers to the ability of an organisation to draw resources through subcontractors, short-term contracts or temp agencies.
- *Robustness*: Robustness or resilience is the ability to *endure* all transitions caused by foreseen or unforeseen changes, or the degree of change tolerated before deterioration in performance occurs *without* any corrective action. This concept indicates that in order to be truly flexible, an entity must not only be able to embrace change by taking steps, but must also be able to embrace change by taking none.
- *Proactive Flexibility*: This concept recognises the fact that an entity is not helpless while waiting for change to occur (Golden & Powell, 2000) and that steps can be taken *in advance* of change as well as in response to it. The simple example of periodic inspection and

preventative maintenance of equipment is a proactive approach to combating machine failure, as opposed to repair and replacement of equipment after failure, which is a reactive one (Gerwin, 1993). *Proactive* versus *reactive* strategies have also been described as *offensive* versus *defensive* strategies (Golden & Powell, 2000) and *initiative* versus *response*.

- *Flexibility Creation*: There is also a need to further analyse the concept of proactive measures. As well as using flexibility to anticipate uncertainty, it can also be utilized proactively to permit a company to positively impact its environment (Gerwin, 1993). This concept argues that proactive steps may “not just anticipate change, but may create it” (Piore, 1989).

4. Conclusions and Future Research

A review of the literature on agile methods, and the concept of flexibility which underpins these methods, illustrates that straight-forward studies of these methods may not be sufficient to determine the merits of their use. When attempting to study agile methods in practice, the first task will be to determine if the method being studied is in fact agile. To determine this, it will be important to check that the method adheres by and large to the 12 principles laid out in the agile manifesto. However, it will be more important from an academic research viewpoint to analyse the method on the basis of its conceptual relevance. Within the context of IS development this task will comprise of three steps:

- When identifying what an “agile” or “flexible” method is, it will be important to ensure that the researcher’s interpretation ties in with the general definitions found in the literature across various disciplines. From this paper, it is obvious that definitions vary wildly both across and within disciplines. However, the researcher must be satisfied that the definition they adopt within the context of their own study on IS development at least considers the way the term “agile” or “flexible” has been used before.
- Secondly, the researcher should not try to study an entity’s flexibility as a whole. In this case no attempt should be made to study how agile or flexible a development team or project is. Instead such a study must look at the sources of flexibility within the project. In the case of IS development the sources would include the members of the team, the project managers, the way the team is structured or the overall ability of the team to “think agile”.
- Finally, the researcher must realise that agility is a very complex concept and must be studied accordingly. Section 3.4 deconstructs flexibility in a number of ways, such as internal and external flexibility, and proactive versus reactive flexibility. In this case the researcher must identify how these components will relate to the specific IS development project being studied. For example, proactive flexibility may be measured by a team’s efforts to build code that is easily modified if requirements change. Reactive flexibility would refer to a team’s ability to change the code after a requirement change is lodged.

In terms of studying modelling techniques within the context of agile methods, it is imperative that the researcher follows these steps. As there is a tendency in agile methods to write code immediately, insufficient thought and time may be dedicated to modelling requirements, architecture, processes for example. Therefore, the researcher must analyse how the different sources of flexibility will handle or hinder modelling techniques. For example, will the overall commitment to flexibility facilitate such design and planning. In terms of flexibility *sources*, will the individuals on the team retain more responsibility of their own work at the expense of overall coherent models? In terms of the *components* of flexibility, an example of proactive flexibility embracing modelling would be to build extensible models for future requirements changes. All components, however, must be considered in order to have a complete study.

5. References

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