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A State Transition Approach to Conceptualising Research: the Project Portfolio Management Domain

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Abstract

Project Portfolio Management (PPM) is an area of organisational activity that attempts to govern the selection and of management of an organisation's ICT projects. As a domain of study PPM is characterised by undisciplined diverse opinion as to its nature and a commercial approach to management standards, business literature and software support. In this paper we examine the use of the State-Transition Approach as a possible means for bringing structure to the study of the PPM domain. We demonstrate its effective use for the analysis of the literature, research question formulation, research design and data collection and analysis. We argue that PPM is an example of a class of problematic, complex phenomena of interest to the IS discipline and that an adaptation of the state-transition approach seems to offer a useful conceptual framework for research across that class.

Keywords

State-Transition Model (STM), Project Portfolio Management (PPM), Research Methodology

INTRODUCTION

This work was motivated by the need to find some conceptual framework within which to conduct research in a domain that has little academic foundation. The Project Portfolio Management (PPM) domain seems to be part of a managerial discourse which, Barberis (2012) says, "thrives upon a certain language that critics would call jargon – what Lord Hennessy describes as 'bullshit bingo'" (see Frankfurt 2005). The domain literature did not seem to contain any conceptual structure that gave a sound coherent account that might underlie a well-constructed research project.

In the search for such a structure the state-transition approach (STA) seemed to offer some possibilities. STA is used for the analysis, description and design of many different kinds of systems and it offered a potential means of classifying the phenomena in the PPM domain and structuring the phases of research into it. In this paper we report on the adaptation of STA to suit research into this domain and speculate its use in research into similar organisational systems.

This paper proceeds as follows. It first outlines the principles of STA and develops an adaptation of STA suitable for general use in organisational research. It then discusses the PPM domain and applies STA as a conceptual framework underlying the stages of a PPM research project. We conclude with some findings of the use of STA in this field of research.

THE STATE-TRANSITION APPROACH

The idea behind the State-Transition Approach (STA) is simple. We are all aware that, depending on our state of mind, we will react differently to the same stimulus. If we are tired or busy we might not take that call, while if we were receptive, we wouldn't miss it. Our state determines our reaction. If we are watching the news and see a dramatic event we might be surprised, but when we see it again, and again, it is no longer surprising. Our state has changed as a result of seeing the first news clip, and we are now in a different frame of mind when we see the same news clip again, so our reaction to it is different. These are the two key points of the STA, that active entities are in a state which governs their response to an event, and events change the state of the entity.

Consider, for example, the lighting in a room with a push button light switch. When the lights are off (state 1) and someone presses the button (event 1) the system turns on the lights (action) and changes the state to on (state 2). When the same event occurs again, the lights are turned off and the system returns to state1. Figure 1 shows this simple case can be modelled in an STA table.

event / state	Transition Event 1: Button pressed
State 1: lights off	Action: turn on lights New state: 2
State 2: lights on	Action: turn lights off New state: 1

Figure 1: Sample state-transition table

This figure shows the interaction of states and events within the limited scope of the simple system being described. More complex systems have many states and many events, both externally and internally generated. This example shows a model of a lighting system that can be used for several purposes: as a specification for the construction of a system, for example, or as a description of an existing system that would allow the effects of an event to be predicted.

Two characteristics of STA that make it useful for description and specification are its clarity and its completeness. The clarity comes from the specification within the table cells - the action the system takes and the new state it moves into are unambiguously described. The completeness comes from the table capturing all known states and events. The more controlled a system is, like the one used in the example, the higher the level of completeness.

Use of STA - Current Domains and Formalisms

The STA has a long history. It underlies the formal specification of a finite state machine described by Turing (1936) and has been used for decades in the specification of technology-based systems (see for example Yourdon (1989), Juliffe (1986)).

The STA is used to analyse and design the interactions of sub-systems in object oriented systems as the actions of one object become the events to another. The model has the advantage of completeness in its specification and explicit mapping to software components so has been adopted into design methodologies including the Unified Modelling Language (UML 1997) and object-oriented design patterns (Larman 1998).

There are a number of different formalisms used to represent the STA when it is used in different situations. The term state transition model (STM) is used when discussing particular formalisms. Figure 1 is an STM of type state transition table. It could be reformulated as a state transition graph (see UML for example). Petri Nets (Van der Aalst 2002) and types of mathematical models are additional formulations of the same underlying approach.

The STA is used in wider domains than software specification. It is used in describing how to conduct a business process, for example, "a state transition model defines the process that your team follows for moving a change request from its submitted state through to a completion state" (IBM 2006).

In the health domain "conceptualizing a decision problem in terms of a set of (health) states and transitions among these states, STM is one of the most widespread modelling *[sic]* techniques in clinical decision analysis" (Siebert 2012). In ecology "State-and-transition models hold great potential to aid in understanding rangeland ecosystems' response to natural and/or management-induced disturbances by providing a framework for organizing current understanding of potential ecosystem dynamics" (Stringham 2003).

The common factor in all these models and domains of STA use is that there is an ongoing, continuous system that is changing its state. STA is a very general idea and takes different forms in different domains. When applied to organisations we will use the label Organisational STA or OSTA.

Organisational STA (OSTA)

It is the ongoing, continuous nature of systems that makes the STA useful in looking at organisational state, change and responsiveness. Much current organisational research, however, does not consider systems this way, but interests itself in the impact of a particular change on an organisation, or the circumstances in which change arises, or the factors that lead to the 'success' of a particular intervention. This is an 'ends-means' or goal-directed

approach. In contrast to the simple 'ends-means' approach OSTA takes a view of the whole organisation as system, one that is ongoing and integrated. The well-being and sustainability of the overall system ought to be aim of any changes to it. A particular ends-means intervention, however, sees only a particular goal and means of its achievement, without necessarily considering either longer-term effects on the system or collateral effects within the system of the means being used.

The issues for OSTA as a way of describing systems and their change are (a) to determine and represent the current state of complex systems, (b) to express desired states in terms of systems indicators and (c) to frame action that changes the system in a way that it produces the desired change to state indicators without damaging other states of the system. Figure 2 shows the general form of OSTA. The *cloud* is the organisational system whose state and transition is the focus of attention. From the critical realist perspective the system in itself is knowable only through the phenomena it presents to an observer. These phenomena are its *state indicators* and the dotted lines represent the instantiations of these indicators by extraction of information from the system, often achieved through business intelligence systems (BI) and management information systems (MIS). The *desired state* of these indicators constitutes a vision of how the system ought to be. This vision is motivated by economic and business values, and by psychological, social, aesthetic, political and other values. *Transitions* are the actions taken to change the system such that the indicators will move from the current to the desired state. These transitions may comprise methods, techniques and tools including software.

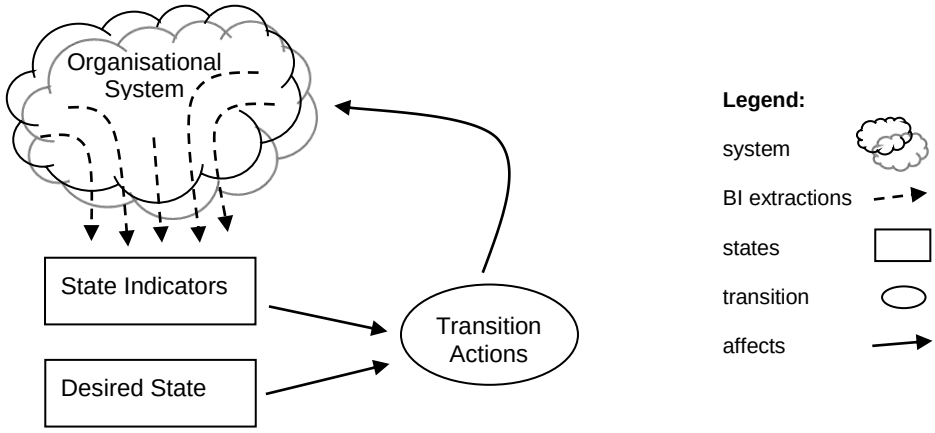

Figure 2: General form of OSTA

As an example of an OSTA, consider the Capability-Maturity Model (CMMI 2010). This model conceptualises and defines a series of five capability levels (states) and the kinds of actions (transitions) that can lead to changes in that state. The early states, for example, are:

> *1) Initial: The ... process is characterized as ad hoc, and occasionally even chaotic. Few processes are defined, and success depends on individual effort.*
>
> *2) Repeatable: Basic project management processes are established to track cost, schedule, and functionality. The necessary process discipline is in place to repeat earlier successes on projects with similar applications. (Paulk et al. 1993: pp8-9)*

and the kinds of transitions that might be taken to move from 1) to 2) include instituting formal process proposal assessment, explicit resource allocation, responsibility specification, and so on.

The complexity of human systems means that OSTA descriptions can never be as full and as prescriptive as they can be in technical systems. The aim is, however, to work towards increasingly clear and complete knowledge of the situation for it is that that allows management practice to better take reliable, transparent, justified and responsible action and research to better frame and explore its analysis of an organisational domain. The challenge surfaced by this model is to see whether we know enough about our systems to be able to describe them in with clarity - do we really know what values we desire for these indicators and do we know enough about our actions to predict their outcomes?

Our contention is that OSTA is a general conceptual framework, lens or point of view that allows any human activity system to be analysed. To examine this proposition an example domain, Project Portfolio Management, was examined.

THE PROJECT PORTFOLIO MANAGEMENT DOMAIN

Portfolio management has been adopted into the ICT management sphere from the finance sector. In that sector assets have differential risks and returns so portfolios are adjusted to best meet the goals of the portfolio owner in changing market circumstances. As an analogy, large organisations invest in a range of ICT projects and these have differential expected returns, business impacts, and internal and external risks. Project Portfolio Management (PPM) is the regime that manages the ICT project portfolio.

PPM is of interest to ICT management because of the claims made for it. Kersten and Verhoef (2003) and Verhoef (2002) claim that firms reduce IT expenditure by 10 to 40 percent using PPM, Laslo (2010) claims that PPM allows an organisation to maintain agility while avoiding wasteful investments and Thorp (1999) argues PPM techniques are fundamental for getting value from IT projects.

There are three main accessible sources of PPM knowledge: research literature, industry standards and PPM software systems. Other sources of domain knowledge not covered here include communities of practice, training courses, seminars, consultancies, and so on.

Research Literature

Portfolio theory was introduced in 1952, focusing on financial investments (Markowitz 1952). The intention of this original formulation of portfolio theory was to determine the particular mix of investments to maximize returns at a given level of risk for the investor (Reyck et al. 2005). The theory was applied by Bard et al. (1988) as a mathematical solution to the selection of Research and Development projects.

Portfolio theory was applied to IT by McFarlan (1981). He argued that management should apply a risk-based approach to the selection and management of IT projects portfolios as unbalanced portfolios could lead an organisation to suffer operational disruptions, or leave gaps for competitors to step in.

The PPM literature has focussed on the following themes: gaps in the portfolio or potential resource shortage (Padovani et al. 2006); management of project interdependencies assuring their mutual compatibility (Maio et al. 1994); right number of projects (Cooper and Edgett 2001; Cooper et al. 2002); role of PPM with programme management (Gareis 2000; Zhu et al. 2007) and strategic alignment (Iamratanakul et al. 2009).

Sarbazhosseini et al. (2013) analysed PPM literature from 1952 to 2013. They identified the three persistent themes being strategic alignment, balanced portfolio, and maximising the investment to risk equation. They showed the PPM literature to be focused primarily on tools and techniques rather than goals and other concepts of PPM like success measurement. Filippov et al. (2010) conducted benchmark studies on the effectiveness of PPM tools and methods to support managerial decision-making, concluding that organisations "should know exactly what they want to achieve before embarking on a transition towards a PPM."

Industry Standards

There is a large 'grey' literature on PPM. Industry standards perhaps provide the most reliable information about practice. In PPM the two main standards are the Project Management Institute (PMI 2006), and the UK's Office of Government Commerce (OGC 2012).

The Project Management Institute (PMI) published 'The Standard for Portfolio Management' in 2006 which defines PPM as "a collection of projects (temporary endeavours undertaken to create a unique product, service, or result) and/or programme (a group of related projects managed in coordinated way to obtain benefits and control not available from managing them individually) and other work that are grouped together to facilitate the effective management of that work to meet strategic business objectives". PMI considers PPM to be "an approach to achieve goals by selecting, prioritising, assessing, and managing projects, programs and other related work based upon their alignment and contribution to the organisation's strategies and objectives. Project portfolio management combines a) the organisation's focus of ensuring that projects selected for investment meet the portfolio strategy with b) the project management focus of delivering projects effectively and within their planned contribution to the portfolio" (PMI 2006)

The Office of Government Commerce (OGC) in the UK developed the Portfolio, Program and Project Management Maturity Model (P3M3) to evaluate organisations maturity levels. The P3M3 has become "a key standard amongst maturity models, providing a framework with which organisations can assess their current performance and put in place improvement plans with measurable outcomes" (OGC 2012). It originated as an enhancement to OGC's Project Management Maturity Model, which itself had origins in Software Engineering Institute's Capability Maturity Model. The P3M3 focuses on seven process perspectives (management control, benefits management, financial management, stakeholder management, risk management, organizational governance and resource management) and assess maturity by evaluating each process perspective to be at one of five levels (awareness, repeatable, defined, managed or Optimised).The P3M3 Maturity Levels indicate "how

key process areas can be structured hierarchically to provide transition states for organisations wishing to set realistic and sensible goals for improvement. The levels facilitate the transition from immaturity to a mature and capable organisation" (OGC 2012).

PPM Software

As PPM practices are information intensive they have attracted enterprise software development. Many of the software products, on the surface, appear to be an extension of project scheduling tools, and have been 'up scaled' to offer an enterprise view of the multiple projects within an organisation at various states of the project lifecycle (Sarbazhosseini and Young 2012).

In a comparative study of PPM software and PPM theory Sarbazhosseini and Young (2012) found that PPM vendors aim to achieve strategic alignment, balanced portfolios, maximised value of portfolios and a centralised source of information. However software did not seem to address issues such as selecting the right number of projects, or ensuring portfolio sufficiency versus overall product innovation goals. Software did, however, seem to have attributes that were not considered in the research literature. These include increasing customer satisfaction, competitive advantage, ease of use and facilities to support visibility and timely management action. McHugh and Hogan (2010) suggest that organisations have become overly dependent on technology and software.

The above brief summary of PPM gives the outline of the domain as it is presented in the literature, industry standards and software. As a domain for research it seems very weak, lacking any theory or rigorous critique. It is not alone in this - many business domains seem to operate on a self-contained and self-perpetuating rhetoric. We now turn to the use of OSTA as an approach to more professional research activity this domain.

USING OSTA TO FRAME PPM RESEARCH

There are many very different forms of research ranging from the experimentation of the physical sciences; the argument and logic of mathematics and philosophy; the anti-positivism of the social sciences and humanities; the exegesis of the creative disciplines and the design of the 'sciences of the artificial'.

A common form of research into human systems follows the following pattern: a literature review to establish the current state of knowledge about a domain, a conceptual framework, a set of research questions or aims, the research design, execution, findings discussion and contributions. As noted in the introduction, the PPM domain seems weak in reliable current knowledge and conceptual framework. The OSTA was therefore used as a means to classify the literature, to assist in the generation of research questions and formulate the data gathering and analysis phases of the research project. In that process OSTA itself was critiqued.

Using OSTA to analyse the literature

The academic and grey literature was collected and initially analysed thematically and temporally. The variety of constructs was very broad with a range of overlapping 'takes' on the domain so the literature review was re-analysed to attempt to classify the constructs into the categories of OSTA and to review some of the diversity in the literature.

State Indicators

While the review is still in progress, few state indicators have been isolated. Much of the literature is value-laden and seems to work backwards from perceived problems. For example, Kendall and Rollins (2003) identify 'too many active projects' as a description of a state, but don't say what the circumstances are that would make a certain number too many. The same is true of indicators such as projects not linked to strategic goals, wrong projects, an unbalanced portfolio, etc. The OGC Portfolio Self-Assessment has the same character.

A variety of methods have been proposed to assess the state of PPM. Cooper et al. (1999) used benchmarking studies, Huang et al. (2006) and Thomas (2007) scorecards and so on, but do not report the indicators as such.

Desired state

The detection of desired states started with an analysis of the goals of PPM. The three commonly cited goals are strategically aligned or linking the portfolio to the strategy, achieving the "balanced" portfolio and maximising the value of portfolio. Less commonly cited goals include: selecting the right number of projects (Cooper and Edgett 2001; Cooper et al. 2002); providing a centralized source of information (Cao et al. 2006); and ensuring portfolio sufficiency versus overall product innovation goals Cooper (2005). P3M3 claims the following benefits: a higher rate of return on investment, greater production efficiency, lower production costs; better quality outcomes, improved customer satisfaction, and enhanced employee morale (OGC 2012). The objectives might be profitability, strategy, risk, etc (Iamratanakul et al. 2009).

A major issue with these goals appears when they are viewed through an OSTA lens. The goals conflate two quite different things - the actual state variable and the justification for why that state is desirable. The justifications seem to be in terms of managerial value (e.g. control) and economic value (e.g. RoI), but these say nothing about what the desired state of the system would have to be in order for these benefits to be realised. OSTA is based in the articulation of a clear and complete set of states but these seem rudimentary, at best, in the literature.

Transitions

The literature covers a range of management actions that change a systems' state. Jeffery and Relived (2004) provided the process of design, diagnosis, opportunities, tools and process which explains how an organization could achieve the PPM objectives by going through a series of steps. Morris and Jamieson (2004) developed processes of Solicitation, Selection, Prioritization, Registration and Resource Allocation as generic portfolio management processes. Cao et al. (2006) suggest that the key processes are Gather, Prioritize, Allocate, Review, Optimize, and Governance. But none of these are actually transitions, they are ways of finding out what transitions might be appropriate.

Iamratanakul and Milosevic (2007) discuss optimization techniques, financial models and financial indexes, scoring models and checklists, probabilistic financial models, and behavioural and mapping approaches as ways to examine the domain. According to Cooper et al. (2001) most companies use these sorts of methods to achieve three main goals namely strategic alignment, resourcing or balancing the portfolio and maximising value of the portfolio.

Constraints on possible transition actions are discussed including financial budget, staff limitations, supporting activities' constraints and so on (Iamratanakul et al. 2009).

To summarise, the literature was reviewed thematically then re-examined using OSTA in an attempt to ground it in actual systems indicators and transitions. This analysis was able to separate out those parts of the management jargon that related to actual states, desired states and the justification for why those states are desired. That said, it is an extensive literature, and when analysed provided a less than extensive set of well-formed attributes in OSTA terms.

Using OSTA to structure the empirical data collection and analysis

Given the conceptual structure of the PPM domain as seen through the OSTA lens, the next issue for the research was how to formulate questions and collect empirical data that might address them. Because of the nature of the literature, the original thematic review produced a very varied set of constructs. An ends-means type research framework would suggest research questions like Why do organisations apply PPM? What kind of actions do organisations take in order to achieve goals? etc. From an OSTA perspective, suggested research questions revolve more around: What are the indicators of state and how are these evaluated? How are desired states determined? How do we know? We contend that OSTA style questions reveal more about the domain than the ends-means style.

Data is being sought from a set of interviews with portfolio managers supported by documentation they make available, across a number of government agencies. The interview protocol involves a set of procedures and instruments used to specify interactions between researchers and study participants including designs for participant contact, an interview data collection instrument, the interview script and analysis techniques. The protocol was desk-checked by the researchers before use. The interview script included items from both means-ends and OSTA perspectives.

To conclude this section of the paper, OSTA, is being used to frame the phases of a research project into PPM. It has offered a structure within which to evaluate the literature, frame research questions and collect and assess empirical data. The use of OSTA is being conducted in parallel with the traditional ends-means approach with a view to comparison.

CONCLUSION

In this paper we have argued that the Project Portfolio Management domain has aspects that make research in it difficult and considered use of the State-Transition Approach as a conceptual framework to bring structure to the study. We have adapted the approach to organisational analysis, calling it OSTA. This we applied to our research domain, PPM, and are critiquing the result.

Our tentative conclusion is that OSTA is an effective framework for the analysis of the literature, research question formulation, research design and data collection and analysis. In the interplay of the model and the approach produced insights and questions and ideas about both the domain and the model.

This paper takes a critical realist stance. Fleetwood (2004) argues that critical realism recognises that a phenomena or entity "is real if it has an effect or makes a difference". He identifies "four modes of reality or four different ways in which real entities may be differentiated, albeit with some overlap". In this paper we recognise PPM as a phenomenon that involves three of those modes of reality: the socially real (involving the structure and function of human activity systems), the materially real (including people, physical actions and artefacts) and the discursively real (as the discourse in the domain can have affect, even it does not refer to materially or socially real entities). "Recognising a distinction between socially and [other] real domains, allows critical realists to recognise the complex way in which discourse is related to extra-discursive phenomena, without collapsing the latter into the former, or confusing them in various ways" (Fleetwood 2004). We argue that the research being done here is challenging a self-serving discourse and attempting to identify that extra-discursive reality within organisations.

The contributions of this paper are that it presents a means for conceptualising management domains and the resultant use of that conceptualisation in the various aspects of conducting research. It is too early to claim practical contributions but it is clear the OSTA could be a fine management analysis method, particularly when well supported by new data, information and knowledge management systems to build the evidence-based for indicator systems and responsible management action.

This research suggests a number of areas for further development. First we speculate that PPM is an example of a class of problematic, complex phenomena of interest to the IS discipline. OSTA seems to offer a useful conceptual framework for research in PPM so it may offer the same to other problem areas in the class. Second, the definition of the relationship between concepts in OSTA and those in wider management ontologies has not begun (note, however, that the language is reminiscent of the BWW ontology). Thirdly, better means of extracting meaningful states and assessing the full repercussions of actions are needed. This highlights the significant role played by data, information and knowledge management systems in the management of a human activity system. Lastly, there is a need for research to build the evidence-based for general PPM indicator systems and management action across the domain.

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