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Evaluating platform architectures within ecosystems

Modeling the relation to indirect value

A thesis submitted to Middlesex University in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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MIDDLESEX UNIVERSITY

Abstract

This thesis establishes a framework for understanding the role of a supplier within the context of a business ecosystem. Suppliers typically define their business in terms of capturing value by meeting the demands of direct customers. However, the framework recognises the importance of understanding how a supplier captures indirect value by meeting the demands of indirect customers. These indirect customers increasingly use a supplier's products and services over time in combination with those of other suppliers . This type of indirect demand is difficult for the supplier to anticipate because it is asymmetric to their own definition of demand.

Customers pay the costs of aligning products and services to their particular needs by expending time and effort, for example, to link disparate social technologies or to coordinate healthcare services to address their particular condition. The accelerating tempo of variation in individual needs increases the costs of aligning products and services for customers. A supplier's ability to reduce its indirect customers' costs of alignment represents an opportunity to capture indirect value.

The hypothesis is that modelling the supplier's relationship to indirect demands improves the supplier's ability to identify opportunities for capturing indirect value. The framework supports the construction and analysis of such models. It enables the description of the distinct forms of competitive advantage that satisfy a given variety of indirect demands, and of the agility of business platforms supporting that variety of indirect demands.

Models constructed using this framework are 'triply-articulated' in that they articulate the relationships among three sub-models: (i) the technical behaviours generating products and services, (ii) the social entities managing their supply, and (iii) the organisation of value defined by indirect customers' demands. The framework enables the derivation from such a model of a layered analysis of the risks to which the capture of indirect value exposes the supplier, and provides the basis for an economic valuation of the agility of the supporting platform architectures.

The interdisciplinary research underlying the thesis is based on the use of tools and methods developed by the author in support of his consulting practice within large and complex organisations. The hypothesis is tested by an implementation of the modeling approach applied to suppliers within their ecosystems in three cases: (a) UK Unmanned Airborne Systems, (b) NATO Airborne Warning and Control Systems, both within their respective theatres of operation, and (c) Orthotics Services within the UK's National Health Service. These cases use this implementation of the modeling approach to analyse the value of platforms, their architectural design choices, and the risks suppliers face in their use.

The thesis has implications for the forms of leadership involved in managing such platform-based strategies, and for the economic impact such strategies can have on their larger ecosystem. It informs the design of suppliers' platforms as system-of-system infrastructures supporting collaborations within larger ecosystems. And the 'triple-articulation' of the modelling approach makes new demands on the mathematics of systems modeling.

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It has been a long journey to this point, during the course of which I have learnt much from my fellow travelers, with some of whom I have published joint papers. Of particular importance amongst these were Richard Boot and Barry Palmer on the place of the individual, Harold Kelner and Robin Wensley on questions of strategy, Vincent Kenny and Marc du Ry on the constructivist and psychoanalytic world views, Nicholas Whittall and Hans Sassenburg on the value of agility, and Bernie Cohen and Antonio de Freitas on the whole drive towards formalization.

I owe a special debt of gratitude to the Software Engineering Institute at Carnegie Mellon University for the opportunity to work with them on the application of these ideas to the engineering and governance challenges associated with systems of systems, and for the support they gave me in writing this thesis. Amongst my many colleagues at the SEI I am particularly grateful to Dennis Smith for seeing what was possible and standing by the work as it evolved.

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Chapter 1 – Core Problem

Outline of Contents

- **What isn't working?** – The supplier has difficulty capturing indirect value derived from the ways in which its products and services are used by its indirect customers.
- **Hypothesis** – The supplier needs a different frame of reference and attendant methods to enable the systematic capture of these indirect forms of value
- **Approach adopted** – The approach adopted by the thesis in its construction.
- **Research Method** – The way the thesis uses the literature from a number of fields to establish its contribution, and tests its value both through applicability to current literature and usefulness through its practical application.
- **Limitations of Research** – the limitations to the applicability and generality of the contribution made by the thesis.

What isn't working?

The architecture of a business enterprise describes the way it creates value for its direct customers, but in the following examples, the architecture is not working for the supplier's indirect customers. Suppliers may be meeting the <u>direct demands</u> of their customers, but they are not meeting their customers' <u>indirect demands</u> arising from the particular ways in which the supplier's customers' customers (i.e. the supplier's indirect customers) are able to understand, evaluate, access and use its products and services within their local context.

Nokia is rapidly losing ground to Apple and to smartphone makers using Android. While Nokia produces devices that are directly useful as a communications device through a network service provider, Apple produces devices that are indirectly useful as a mobile computing platform that, amongst other things, is a communications device. As the world's largest provider of mobile phones, Nokia has failed to produce devices that can compete with smartphones as platforms for supporting the indirect demands of phone users. Its chief executive attributes this to Nokia's not having a competitive smartphone <u>ecosystem</u> that combines user-friendly hardware, software and services [1]. This ecosystem emerges from all the possible uses of the smartphone supported by applications (i.e. 'Apps'), based on their convenience and relevance in ever-changing contexts-of-use.

In acquiring Intelligence, Surveillance, Target Acquisition and Reconnaissance(ISTAR) capability, the UK Ministry of Defence (MoD) shows itself driven "bottom-up" in the acquisition of numbers of ISTAR capabilities. But to ensure that these systems are able to deliver indirect benefits to operational missions in theatre, they need to work together, and to be directed and exploited at the level of the mission itself [2]. A report on the acquisition of ISTAR Uninhabited Aerial Systems (UASs) has shown that as much as the entire cost of acquiring UASs was being spent on short-term 'fixes' to enable their effective use at this mission level [3].

A study of orthotics provision [4] found that, because of the chronic nature of conditions needing orthoses, changes to the orthotics service would enable every £1 spent on orthotics to save the UK National Health Service (NHS) £4 [5]. Despite this, and the UK Government's rhetoric concerning the need for patient-centric care [6], the orthotics service remains focused on direct provision of equipment and orthoses continue to be under-used in creating indirect benefit . The study proved that the ongoing nature of care required by orthotic patients was better suited to a primary care led service, but the orthotics service remained in an ancillary role within the acute care system. To change this required a systemic change that represented a structural challenge to the NHS [7].

The supplier's product or service might provide direct value for its direct customers. But in each case the indirect value of the product or service to its indirect customers depended on the way it could be used alongside other products and services within the larger contexts-of-use of those indirect customers (i.e. of the phone user, the mission commander, or the elderly person). At the same time, the tempo of variation accelerated in the way the product or service was needing to be used within these larger contexts-of-use. This made the potential variation much greater in the way these larger contexts-of-use could be defined, facing the supplier with multiple contexts-of-use each with its associated indirect customers.

These different perspectives on value are summarized in the following table, the nature of the demand defining the customer context-of-use in which value was being created. This meant putting the primary emphasis on the way the context-of-use was defined, and not on the person associated with that context-of-use. In the UAS case, this meant that the direct customer associated with the direct demand for ISTAR capability (the UAS operator) was different to the indirect customer associated with the indirect demand of the operational mission (the mission commander). For the other two cases, even though the same person was involved with both direct and indirect demands (i.e. the phone user or the elderly patient), the direct customer associated with the direct demand for using the phone as a communications device was the network service provider, while the direct customer associated with the direct demand for an orthotic treatment was the clinician. The contexts-of-use for these direct demands were more narrowly defined than the larger contexts-of-use in which there was an indirect demand for arranging a date or for managing the patient's condition over time.

Table 1: Direct and Indirect Value

	Nokia/Apple	UASs	Orthotics Provision
	Direct Value		
Direct Demand	Phone use as a communications device	ISTAR capability	An orthotic treatment
Direct context-of-use	Making a call from a mobile phone	ISTAR operations	Presenting problem
Direct Customer	Network service provider supporting phone use	UAS operator	Clinician treating patient
	Indirect Value		
Indirect Demand	Smartphone as a mobile computing device	Operational mission	Ongoing orthotic care
Indirect Customer	Phone user's indirect demand	Mission commander	Elderly patient
Larger context-of-use	e.g. arranging a date	Mission situation	Patient's condition
Tempo of Variation	In types of indirect demand	In types of mission	In types of condition

In each case the type of business model being used by the supplier was focusing on the direct value of providing the product or service to its direct customers in such a way as to preclude focusing on these larger contexts-of-use (i.e. the supplier was focused on the network service providers, the operators of the UAS, or the elderly person's immediate problem). This led to a lack of ability to benefit from creating indirect value. In some cases, this narrowness of focus extended to the ways in which procurers (if not the customers themselves) expected a product or service to be useful, as in the case of the UAS.

A number of factors contributed to this inability, but foremost amongst them was a business architecture that did not enable a supplier's indirect customers to determine the particular way in which a product or service could be aligned with others' products or services within the indirect customer's context-of-use. For example, the Nokia architecture had limited the ways in which the phone could be used in combination with other services to a much greater extent than the iPhone; the business architecture used to acquire the UAS had limited the operational uses that could be made by operational commanders of the live feeds from its sensors; and the business architecture used to acquire the orthotics service had limited its use to the acute circumstances in which a referral for an orthosis could arise.

Distinguishing direct and indirect demands

The distinction between direct and indirect demands is relative to the way the supplier defines its products or services, indirect demands arising from the customer's customers, which are also the supplier's indirect customers. While the costs of satisfying a direct demand are generated by the supplier, the costs of aligning various products and services to satisfy an indirect demand are generated partly by the supplier's customer and partly by the indirect customer. In each of the cases examined, these <u>costs of alignment</u> were higher than they needed to be because of the way the supplier's business had been defined and the relationship with the customer had been arranged.

For Nokia, the direct demand from the service provider was for a mobile communications device with numbers of features that made it convenient for the service providers' customers to use as such. The indirect demand arose from the way Nokia's indirect customers wanted to use the capabilities of the mobile phone in combination with the capabilities of other devices, for example using their present location to identify nearby restaurants, make a booking, text messaging the details to a friend, and putting the details into their diary. The Nokia phone met the direct demands of the service providers well, but the indirect customers had to satisfy their indirect demands independently because they fell outside the business architecture realizing Nokia's competitive strategy, and varied at a faster tempo than the supply of the phone itself.

For the UASs, the direct demand was for a Royal Artillery Regiment to be able to position a sensor over a battlespace and to relay live feeds back to a command post under a variety of conditions. The indirect demand from a mission commander was to be able to dynamically align the UAS capability with other capabilities of people on the ground, satellite imagery and fast jets. The UAS met the direct demands well, but other means had to be used to bring the various capabilities together within the context of a particular mission at a tempo adequate to respond effectively to the indirect demand. In this case, providing support for the indirect demands fell outside the scope of the UAS's capabilities because the MoD's acquisition process had excluded their consideration in establishing an acceptable cost for the UAS capability.

For the orthotics supplier running a clinic within the NHS, the direct demand was for an orthosis provided by an orthotist clinician in response to a referral from another clinician typically within an acute hospital, but also potentially from a general practitioner. The indirect demand arose from the way the orthosis interacted with other aspects of the patient's condition and its prognosis within the context of the patient's daily life, in this case at the tempo of the changing condition. Knowledge of the indirect demands arising from these other aspects lay with other clinicians and with community services. They were not part of the formal concerns of the orthotist because of the way their role had been defined under contract to the orthotics supplier. The role was defined in this way because the hospital's contract with the supplier judged orthoses to be ancillary to its services, and because the remit of the national purchasing authority governing orthoses only extended to the provision of the orthosis itself.

Starting from the particular relation in each case between the supplier and the direct demands (service provider, Royal Artillery or orthotics clinic), the indirect demands were always associated with some larger situation in which the indirect customer (phone user, mission commander, elderly person) was aligning various products and services in ways that varied at a faster tempo than that of the direct demand itself, for example arranging a blind date, interdicting a fleeting target or managing the complications of diabetes. It is these <u>indirect</u> <u>customer situations</u> with their tempo of change that define the contexts-of-use within which the indirect customers create indirect demands on the supplier. These are the demands which the supplier could exploit, but has chosen, consciously or otherwise, not to.

Placing the indirect customer at the center of the supplier's business model

A business ecosystem is defined as socio-technical, being made up of a number of operationally and managerially independent organizations interacting with each other in response to some variety of demands varying at some tempo. The supplier-centric model of an ecosystem based solely on the supplier's <u>knowledge</u> of direct relationships with its customers and competitors has the virtue of simplicity. Adopting an indirect customer-centric view of an ecosystem capable of including a dynamic variety of indirect demands from indirect customer situations involves changing the point-of-view from which knowledge of the ecosystem is constructed as well as constructing a capability to support dynamic linkages between indirect customers and suppliers. In the examples considered, there had not been until recently a sufficiently compelling reason for the supplier to move to an indirect customer-centric view in the way its knowledge was constructed.

The supplier's failure to reduce the indirect customers' costs of alignment in each case represented an opportunity not considered for capturing indirect value beyond the direct value of their product or service. The reasons in each case were different (Nokia's competitive strategy, the MoD's acquisition approach, the role defined for the orthotics clinic within the acute hospital), but all resulted from the presumption of the supplier being that their business model should be defined solely in terms of meeting the direct demands. A number of authors have nevertheless argued that satisfying indirect demands should form an important part of the supplier's business architecture [8] [9] [10]. Why then the failure to do so in these cases where there was clearly a need so to do?

The challenge presented by indirect demands

For suppliers to make indirect demands their business, the supplier has to be able to consider how to reduce its direct and indirect customers' costs of alignment across a wide variety of indirect customer situations. This in turn involves considering the different level at which indirect demands have to be defined, including consideration of how the customer's and others' products and services can be dynamically aligned to each other within the contexts-of-use the indirect customers create. In effect, the supplier has to be able to consider its role as a member of an ecosystem supporting indirect customer situations alongside competing or complementary suppliers and customers. An ecosystem platform architecture[11] describes a supplier's business architecture capable of supporting indirect demands in this way (for example in the way the smartphone supports an ecosystem [12]).

The agility of an ecosystem platform architecture is measured by the variety of indirect demands that it can support at the tempo of variation in those indirect demands. What is not working in these cases is therefore a way for the direct and indirect customers of the supplier to agree how direct and indirect forms of value can be created within their ecosystem through ecosystem platform architectures with the requisite agility. This agreement depends on shared knowledge of the way the larger ecosystem is constructed. Without the ability to agree how direct and indirect forms of value can be created as joint members of a larger ecosystem, suppliers and their direct and indirect customers are each forced to pursue value independently of each other.

Hypothesis

A supplier needs to be able to capture indirect value if it is to support indirect demands. To identify opportunities for capturing indirect value, a frame of reference is needed within which knowledge of supplier-customer relationships can include relationships to indirect customers forming the larger ecosystem within which the supplier is competing.

Within such a frame of reference, methods need to be established that can understand the competitive identity of the supplier's business within this larger ecosystem, with attendant consequences for how value, risk and business architecture can be understood.

Lacking this frame of reference and methods, it is very difficult for suppliers to identify and pursue these opportunities, and very difficult to make the concepts of architecture and agility operationally tractable, limiting suppliers' ability to generate indirect value.

Approach adopted

The frame of reference and attendant methods put forward by this thesis have emerged during the course of consulting to a wide variety of industries: finance, telecommunications and computing services, professional and research services, retailing, logistics, manufacturing, defence, utility and care services, and government departments.

The published works that form the primary basis of the thesis are by the author alone. An important part of the author's approach, however, has been not only to test the frame of reference and methods in practice, but also by publishing works jointly with others spanning different disciplinary boundaries. The scope of this boundary-spanning work is outlined by the Epochs in Chapter 2, which account for how the works relate to each other.

The frame of reference and its attendant methods of projective analysis are then put forward in Chapter 3. The arguments used are made with respect to three domains: the iPhone, military and medical domains, other domains being considered in discussing the generalization of the frame of reference and methods. A particular implementation of the methods of projective analysis is established in Chapter 4, and the value of its use described in Chapter 5. Chapter 6 then concludes by considering the implications of both frame of reference and its methods for further work.

Research Method

The problem of capturing indirect value presents the supplier not only with the complexity of situating and modeling its own dynamic behavior within the larger ecosystem in which it competes, but also with the complexity of a modeling process in which the processes determining what can be of value within that larger ecosystem have to be modeled, including the processes of the modelers themselves.

The research method used by this thesis starts with the modeler, by considering what forms of *knowledge* are implicit in the way a decision-maker understands the behavior of a supplier. These different forms of knowledge assume that the decision-maker is embodied, meaning that value is understood to be not only in the way behaviors in the environment can be engineered, but also in the way the decision-maker anticipates experiencing differently engineered behaviors. Knowledge may be useful, but it also serves interests.

The literature drawn on in this reasoning spans the domains of psychology, systems and competitive strategy, but does not address the relationship between the embodied decision-maker and the supplier as itself embodying an *enterprise identity*. This relationship is understood as a process of identification, drawing on psychoanalytic and social constructivist literature. The identification is understood as being with task systems supported by social processes, which social processes are themselves expressing a particular way of valuing the behavior of the enterprise. It is therefore this identification that is expressed by the supplier's model of itself.

A contribution of the thesis is the *triply articulated model* representing that which is being identified with. By making the relationship to the experience of value explicit, this triply articulated modeling is therefore able to represent the supplier's relationship to indirect value, by articulating the ways in which *customers* experience value as distinct from the way supply-side stakeholders experience value. (The experience of value is not assumed to be the same as the economic value attached to that experience). Triple articulation is thus able to represent the architecture and economic structure of the relationship between the supplier and the larger *business ecosystem* within which its behavior is being valued by its indirect customers.

The research method tests the value of triple articulation by demonstrating its relevance to new forms of competitive advantage and the associated economics of multi-sided markets, both of which are emerging in the current literature. It also tests its value by deriving methods of analysis based on triple articulation and showing how these apply to a number of cases.

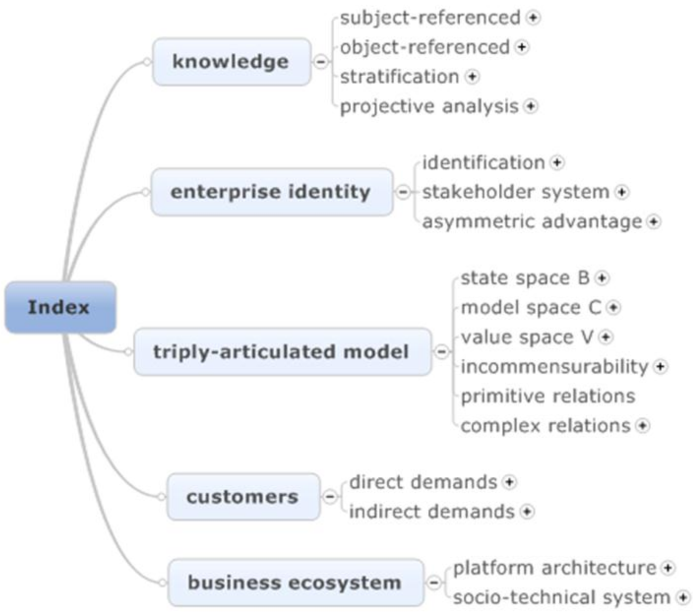

Figure 1: The main index headings associated with the research method

Limitations of the Research

Using a research method that started with the modeler's relationship to the client enterprise rooted the research in the problems associated with the complexity of enterprises and ecosystems encountered 'in the field'. But it thereby also limited the generality of its claims for the use of its methods. What methods were useful within these particular contexts cannot be assumed to be generally useful.

Working with this complexity also prevented the work from falling within any one well-defined field of literature. Using a research method that examined ex-post the consistency of its claims with the literature of a number of different fields through a process of translation established where gaps lay between those fields and the problems under consideration, but was nevertheless limited in its ability to identify whether those gaps were significant in any one of those fields' own terms. This was a second limitation of the research.

Finally, while the research method explored the extent to which these problems were present in literature relating to domains beyond those it considered explicitly (i.e. the iPhone, military and medical domains), a third limitation is in the generality of the problems considered.

Chapter 2 - The Body of Work

Outline of Contents

Introduction

No enterprise is an island entire unto itself. It must depend upon suppliers, best its competitors and comply with laws while meeting the demands of its customers. The people running hospitals know that. And yet the dominant conception of the enterprise has been as a singular sovereign entity able to create and sustain its own identity in the interests of its stakeholders, based on the way it creates value for its customers. Competitive strategy has thus focused on sustaining the competitive advantage of the individual enterprise, the socio-technical insight being applied to the way individuals take up their roles within the enterprise. The treatment episodes that hospitals offer have to be of the highest quality, while provided at the least possible cost.

Information technologies are changing this exclusive focus on the enterprise. While the enterprises use these technologies to extract ever greater efficiencies from their existing business models using less and less people, the customers are able to be better networked than the enterprises that supply them. The effect is that while enterprises focus on the direct uses made of their products and services, customers focus on combining these products and services in support of the various situations they encounter in their lives. These situations constitute indirect uses of suppliers' products and services by suppliers' customers' customers. Thus while the hospital's customer is the condition needing a particular type of treatment, the customer of their customer is the patient with the condition needing it to be managed through its life. Shifting the focus of the enterprise to these indirect demands creates a new kind of challenge for the enterprise.

The Body of Work on which this thesis is based (Chapter 2, p9) explored the limitations of the conception of the enterprise as a sovereign entity. In the first Epoch it explored these limitations in terms of the different kinds of knowledge the enterprise needed to use, and its ultimate dependence on particular individuals' interpretations of what was valued by its customers. The hospital depended ultimately on its doctors' ability to treat patients. In the second Epoch it explored these limitations in terms of the way these forms of knowledge could be taken up by the enterprise when they challenged the identity of the enterprise itself. To what extent could the doctors determine what treatments were offered by the hospital? And in the third Epoch, it explored these limitations in terms of the dependence of the identity of the enterprise on its place within the larger business ecosystem in which it at least implicitly collaborated with other enterprises to create value for its indirect customers

– its customers' customers. How were the interests of the hospital to be aligned to the through-life interests of its patients?

The exploration of these limitations arose within the context of consulting practice within many different industries – the drive to understand them being in response to the problems presented by client organizations. Thus these same limitations appeared in industries as diverse as defence, professional services, specialist engineering and retail catering. Three lessons are drawn from the Epochs (Chapter 3, p17): firstly, that the unit of analysis has to shift from the individual enterprise to patterns of demand within a business ecosystem of enterprises and their customers; secondly, that this shift arises from a change in the differences in know-how in terms of which enterprises must compete, to include differences in the way demands themselves are defined; and thirdly, that these differences in know-how therefore have to be understood in terms of their consequences for the way supply and demand are dynamically aligned at the level of the ecosystem itself.

These three lessons define the need for a method of analysis that can analyze the behavior of the business ecosystem across three independent dimensions of interest: the behavior of task systems, the constraints placed on these task systems by social organization, and the stakeholder values determining in whose interests these constraints are organized. A method of modeling is described that is capable of supporting this method of analysis (Chapter 4, p37). This method is distinguished by the way it is able to articulate the relations between this triple articulation of task, sentient and stakeholder systems, providing the means for analyzing different architectural characteristics of the ecosystem.

The purpose in developing this method of modeling is in order to quantify the forms of indirect value that arise within a business ecosystem, to identify the risks that any given supplier faces in seeking to capture indirect value, and to define the characteristics of the forms of organization and platform architectures through which such risks may be mitigated. Examples of the use of the method are described, in which significant commercial opportunities are identified in the pursuit of indirect value (Chapter 5, p57).

Finally, implications are drawn (Chapter 6, p73): on the challenges both suppliers and government face pursuing indirect value, on the way the semantics of systems of systems supporting platform architectures have to be understood differently, and on the different kinds of mathematics involved in such different understanding of semantics.

Knowledge in decision-making (Epoch 1, 1979-1990)

This Epoch started with a project on supporting management decision-making, funded by the National Development Programme in Computer Assisted Learning [13]. Its focus was on the role of the individual in the decision-making of a supplier. The background theory used was personal construct psychology [14], and its approach was based on distinguishing between subject-referenced and object-referenced forms of knowledge used in making judgments **[15]**. (References in bold were published by the author alone and are in the attached CD-ROM.)

Subject-referenced forms of knowledge and reflective analysis

The analysis of subject-referenced forms of knowledge used methods of reflective analysis derived from repertory grid techniques [16]. These methods distinguished between consensus building (what we can all agree on), reflective analysis (establishing what we particularly know as individuals) and establishing shared strategic intent (what we are going to do together) **[17] [18]**. The learning generated was particular to the person doing the learning, concerned with establishing meaning in terms of the individual's relationship to their experience [19]. In considering these forms of knowledge, the individual was the originator of decisions made by a supplier, the origination taking the form of intentional action. But the individual could also be the customer.

Analysis of these forms of knowledge in terms of the expression of choices in language led to understanding individuals' use of the medium as being triply articulated **[20] [21]**. Object-referenced knowledge could be represented in a medium that was doubly articulated, referring to the way its form and content could be varied independently of each other along syntagmatic and paradigmatic axes. Its triple articulation arose from the variation along both these axes being understood in ways that were particular to the speaker or listener. Thus the illocutionary force of a speech act was its ability to produce effects of meaning in the listener [22] through the way the speech act was experienced, rendering the speech act performative in its effects. The basis of illocutionary force was described as a third articulation that was not directly accessible in the languaging medium itself because of the medium itself being only doubly articulated. The third articulation was therefore implicit in the way the individual used the medium in relation to themselves as context to the speech act, whether as speaker or listener **[23]**. In these terms, as speaker the individual takes up the position of supplier; and as listener the individual takes up the position of customer.

The methods of reflective analysis were used by individuals within learning processes in which it became apparent that questioning their experience of illocutionary force also meant working with the individual's experience of anxiety **[24]**. This experience of anxiety was approached in terms of the different ways in which the individual could avoid anxiety by getting 'stuck' i.e. by avoiding choosing. The different ways of getting 'stuck' provided ways of describing the different ways in which individuals guaranteed the truth of what they felt they knew **[25]**, leading to the question of the individual's 'aesthetic imperative' - the ethical question of by whose authority the individual made decisions **[26]**. It was the need to define the basis of identity and authority that led to the work during Epoch 2, in which these concepts were extended to apply both to the enterprise within its context, and to the customer as context-of-use.

Object-referenced forms of knowledge and projective analysis

The research project examined management decision-making used white-box simulations to represent the objects and their relationships within the manager's decision-making environment [13]. Simulations created to be used in this way included simulations of competing manufacturing businesses and of the energy industry **[27]**.

These white-box simulations separated relationships between an individual's decisions and others' behavior in terms of whether or not the relationship was 'structure-determined' or 'structure-determining'. A structure-determined relationship to behavior meant that the behaviors of others were constrained by the way the world had already been structured; while a structure-determining relationship meant being able to impose structure on the behaviors of others through being able to determine how behaviors were to be constrained: some decisions were determined by the way the world had already been structured by the simulation, while others were determined by the social choices individuals were able to make within the simulation.

Making this distinction in the way managers understood themselves and their environment meant being able to distinguish between these different forms of structure-determination, leading to an early form of projective analysis used to design simulations based on managers' models of their own (object-referenced) environment. (Methods of projective analysis were to become an expression of the frame of reference for modeling the structural characteristics of ecosystems). This distinction included the particular relation of 'purposeful systems' (individuals) to other kinds of system whose behaviors were simply reactive or goal-seeking (for example in [28]). Projective analysis was in this sense contrasted with reflective analysis, used to model the way value was created within a particular industry and to model the industry's relationship to demand through the way the market was organized. The layered matrices used to describe this relationship formed an early version of stratification, in terms of which the formulation of structural 'gaps' in connectivity within different layers of the stratification were proposed as a way of identifying strategic opportunities, in this case within the glass industry [29]. The initial forms of analysis of these gaps were based on Q-analytic methods [30], the need to develop more formal methods for analyzing structural 'gaps' leading to the work done during Epoch 2.

Working as a consultant within organizations involved encountering many different models of the way the behavior of a business enterprise was structured in practice, including both those espoused top-down by senior management and those being used in practice [31]. Using methods of projective analysis within organizations therefore meant addressing the limitations of top-down strategic analysis. This included dealing with the breakdown of the product-market as a unit of analysis, and the need for a more dynamic view of the world based on channels, customers and competitors organized in relation to the use-situations of actual customers. This more dynamic situation was expressed in terms of a need for 'middle-out development' [32], based on distinguishing between market niches defined in terms of the direct demands of customers on suppliers, and market clusters forming around indirect customer situations creating particular kinds of indirect demand. Approaches to modeling this more dynamic complexity using methods of projective analysis emerged from work at this time with the retail strategy of a regional brewer [33]. Epoch 3 involved developing a strategic rationale for middle-out development. Considering suppliers and customers to be different types of enterprise, methods of analysis were developed during Epoch 3 that could model the enterprise within a more complex business ecosystem.

The triple articulation of models of identity (Epoch 2, 1990 – 2004)

Lacan, Third-Order Cybernetics, and the challenge of the case

The beginning of this epoch was marked by a review of a book on accountability hierarchies, and the questions it raised concerning the identity of the enterprise itself **[34]**. The questions of identity and authority from Epoch 1 were the starting point, and the approach was to consider how the embodied individual constituted himself or herself as part of an enterprise through 'discourse': "embodied" because this process of constituting an identity was assumed to be inextricably bound up with the individual's experience of their own embodiment with which they identified themselves.

Using a Lacanian frame of reference, 'discourse' here was not just discourse as used in linguistics (for example in discourse analysis [35] [36]), nor was it just the particular forms of discursive practice through which professionals made their identities as such manifest (for example in a Foucauldian understanding of Power/Knowledge [37] [38]), but rather discourse as the process of social formation of the individual's relation to their own embodied being [39]. This Lacanian way of framing discourse provided a way of considering the individual as embodied in order to include the invention and sustaining of an identification between that embodiment and an observing 'I'. With the difficulties of sustaining this identification came the individual's relation to what was left out in that identification, leading to anxiety and 'stuckness'.

An economy of discourses was formulated as the variety of ways in which individuals' identities could be supported by their relation to an enterprise, but which in combination also described the emergence of an identity for the enterprise itself as a particular social formation amongst that variety of ways [40]. This formulation of the enterprise as a social formation was framed in terms of a third-order cybernetics that conserved a particular organization of the enterprise, and in which the combined behaviors of individuals emerged from the way that organization supported their identities through their taking up of roles within an economy of discourses [41]. This again raised the question of how to represent the way the enterprise supported their identities, taken up in Epoch 3. For example, how did the way the design of the information systems of an enterprise constrain the forms of business development that could be considered by its managers **[42]**.

Three dilemmas were derived from this understanding of the way the enterprise supported individuals' identities **[43]**. These dilemmas reflected structural 'gaps' in the way the enterprise itself was able to support identities, and translated into questions for the consultant concerning the ways in which the enterprise was able to pursue sustainable competitive advantage [44]. These dilemmas provided a way of understanding the link between how the enterprise competed and how it supported the identities of its managers [45], in which the different discourses defined how different 'truths' about the enterprise were held in relation to each other [46].

This view of an enterprise led to the need to describe how the layers of its architecture were kept in dynamic alignment both with each other and with the demands on the enterprise as they changed and evolved [47]. These issues were explored in the context of the challenges facing a Specialist Care Organization [48]. Referring back to the book review at the beginning of this Epoch, it led to a critique of enterprises based on the privileging of a particular relation to demand in which the enterprise was by definition an accountability hierarchy. This critique was expressed in terms of the three dilemmas that emerged in the how the enterprise responded to demands **[49]**, and in terms of a stratified form of organization that was orthogonal to hierarchy, emerging from the particular way the enterprise had of defining its relation to demand **[50]**.

Projective analysis modeling

During this period a Eureka research project was undertaken, funded by the DTI, and aimed at developing triply articulated methods of modeling[51]. The result was the development of particular methods of projective analysis [52], and formal methods for analyzing patterns in the models. These patterns were used to define a stratification of the ways in which an supply-side and demand-side organization were aligned with each other, which could then be analyzed for structural 'gaps' that emerged within and between its different layers [53].

In the latter part of this period, there were a number of client assignments concerned with developing the use of these methods: with British Telecom, examining the root causes of errors in their relationship to their customers arising from the impact of digitization; with the MoD, examining the ways in which the procurement of defence capabilities were 'blind' to network enablement within the larger defence ecosystem; and with the NHS, examining the ways in which the orthotics service could be better enabled to meet the indirect demands of its patients [4]. In each of these cases, implementation was limited by the client enterprise because of the levels of change they involved. This was not an issue of how to work with these different forms of analysis, but of how to address the strategic framework implied by them. Within this strategic framework, the issues of anxiety and resistance had to be worked with as an explicit part of the overall process **[54]**.

Working within ecosystems (Epoch 3, 2004 – 2010)

The challenge of the asymmetries

Such work demanded different ways of working with teams and leadership, in which the assumptions implicit in the decisions of leadership could be made accessible [55]. This had to take into account the relation of leadership to the identity of the organization [56], distinguishing between the interests of the leadership and its identification with the enterprise itself **[57]**. It assumed a view of the challenges facing enterprises and leadership based on their relation to demand **[58]**, and led to a need for new ways of enabling organizational infrastructures to support edge-driven approaches [59], together with a need to delegate decision-making authority to the edge of the enterprise where it encountered individual indirect demands within indirect customers' contexts-of-use [60].

This required a different way of understanding competitive strategy based on the way the supply-side was aligned to the demand-side in the form of a stratification, with three different types of asymmetric advantage being distinguished in the way this was done, and with the stratification as a whole distinguished from hierarchy **[61]**. This stratification was organized in relation to the indirect demands arising in indirect customers' situations that were by definition asymmetric to any supplier's assumptions about direct demands from its direct customers. These asymmetric demands presented a double challenge to any enterprise responding to them **[62]**, involving a different kind of agility **[63]** reflecting the way it was able to respond to customers' demands depending on how they varied over time **[64]**, requiring changes in the approach to governance **[65]**. This agility involved a different type of economics associated with the customer's organization of alignment **[66]**, enabling customers to vary how they aligned themselves in support of particular indirect demands **[67]**.

The concept of strategy at the 'edge' was based on distinguishing the particular way in which a supplier defined its identity with respect to demand **[68]**. The organization of demand itself had to be understood as dependent on the particular contexts in which the indirect demands of indirect customers arose **[69]**, creating a variety of possible relationships, depending on how much of that context was related to by the supplier **[70]**. Because of the nature of the double challenge, relating to indirect demands tended to create a structural 'gap' in the middle of the enterprise where the supply-side and demand-side imperatives met **[71]**. If meeting the complexities of the demand-side were not to be left to the individual **[72]**, the result was the need for a different approach to organization that could create effective agility for responding to the 'edge', and which created a new challenge for leadership **[73]**.

A fundamental difficulty emerged, based on having to work with multiple perspectives on the way value could be created, in which the enterprise was increasingly a collaboration between multiple enterprises and customers that were managerially and operationally independent of each other. These communities of interacting enterprises and customers were referred to collectively as forming a socio-technical ecosystem **[74]**, within which many different forms of collaboration were possible **[75]**. Modeling these involved modeling more than single enterprises **[76]**, while still distinguishing structure-determining processes from structure-determined ones **[77]**. These ecosystems had their own cycles in the way they developed new ways of generating value at different levels **[78]**, together with new kinds of disenfranchisement if they did not **[79]**.

Working with multi-sided demands within socio-technical ecosystems

Half way through this Epoch, Boxer Research Ltd (BRL) carried out a demonstration project for The Software Engineering Institute (SEI) at Carnegie Mellon University (CMU). It used its projective analysis methods on a NATO case to evaluate the different types of risk facing the use of airborne warning and control system (AWACS) capability given the changing role of AWACS anticipated within the defence ecosystem over the next decade [80]. BRL subsequently licensed the SEI to use and develop these methods, which came to be seen by the SEI as a means of analyzing and modeling interoperability in systems of systems [81]. These different types of risk arose from an absence of the appropriate type of agility, and reflected the double challenge that a supplying enterprise faced in bringing together capabilities from multiple suppliers, and then keeping those composite capabilities aligned to dynamically changing forms of indirect demand [82]

Working with the SEI involved clarifying the relationship of the projective analysis methods to their existing system-of-system (SoS) practices [83], to the distinction between hierarchical and stratified forms of organization in SoS environments [84], and to the role of tempo **[85]** in determining the particular challenges presented by collaborative systems of systems [86]. These collaborative environments had to recognize and support much greater varieties of indirect demand [87], enabling distributed forms of collaboration [88] that could not be supported by the existing single-enterprise approach to the business architectures of suppliers [89].

The focus of the SEI had been on the interests of the developer of systems of systems. But these collaborative environments meant that new systems were always being deployed alongside other systems already in the field, adding an emphasis on the alignment of existing systems in addition to the acquisition of new systems [90]. This meant adding a focus on the larger socio-technical ecosystems within which new systems were being deployed [91]. This required a change in the level at which the value of systems needed to be defined, to include the ways in which they were used [92], and to consider this on a through-life basis [3]. This involved working with the concept of multi-sided demands within indirect customer situations [93], in which the impact of a system on the indirect uses it could support became at least as important as the direct uses it supported [94]. Identifying the value of these indirect uses [95] implied changes to the approach to governance within the larger ecosystem [96] and to what constituted 'the enterprise' itself [97].

Chapter 3 – Lessons learned from the Epochs

Outline of Contents

- **Introduction** – the difficulty in supporting indirect demands
- **Creating Value in Ecosystems** – relating different forms of value to different types of competitive advantage within an ecosystem.
- **Modeling asymmetries** – understanding the modeling challenges that flow from the different types of competitive advantage.
- **Value Stratification** – understanding the way different forms of value are combined within an ecosystem from the perspective of the indirect customer as well as from that of suppliers.
- **Conclusion** – Projective analysis as providing the means of modeling the greater complexity associated with supporting indirect demands in ecosystems

Introduction

A supplier responding only to direct demands need only concern itself with the way it manages its own activities, the fact of there being a market for its products or services being sufficient, so long as it can sustain competitive advantage in their supply. There will always be such opportunities for suppliers, but the fact of there being a market was not sufficient in the case of Nokia, and all three examples led to significantly higher costs for the indirect customer than would have been necessary had the suppliers pursued indirect value. The scale of this indirect value is quantified in Chapter 5. In all three examples a significant opportunity existed for the supplier to create indirect value through the way it reduced these costs while increasing its own revenues, by supporting the indirect demands of its indirect customers. Examples of this being done successfully are the iPhone in the smartphone ecosystem [11], Thales in the defence ecosystem [91], and Kaiser Permanente in the healthcare ecosystem [98].

The difficulty in supporting indirect demands lies in being able to understand well enough how the indirect customer's business works in order to be able to add value to it through reducing the costs of the way the indirect customer creates value. This requires the supplier to understand the way its ecosystem works, and to adopt a way of competing that enables the supplier to capture these indirect forms of value. This is a strategy based on a <u>platform architecture</u> because the supplier aims explicitly to support the relationship between its own and others' products and services in creating indirect value. For example, the iPhone enables the use of others' applications, the UAS enables the interoperation of others assets in theatre, and the orthotics clinics support the alignment to the patient's condition of multiple episodes of care involving different clinical specialisms.

This requirement changes the way the supplier must understand its own business in order to be able to target indirect value through increasing its agility as an ecosystem platform, and to be able to mitigate the new forms of risk that emerge as a consequence. At the heart of targeting indirect value lies a necessarily different approach to modeling the value-creating relationship between the supplier and its ecosystem.

Creating value in Ecosystems

Describing both the supply-side and the demand-side

The processes by which a supplier comes to define what is in the interests of its stakeholders are social processes. These social processes enable it to agree a definition of the problems it must solve, even though these may change with changing circumstances. Once defined, however, a supplier must realize any proposed solutions through task systems that, in order to realize the interests of its stakeholders, may be under its own control, or bound to it through contractual relationships with other suppliers. Either way, task systems interact with each other through transactions, while suppliers and customers interact with each other through contracts [99], organizations and their task systems together constituting socio-technical systems [100].

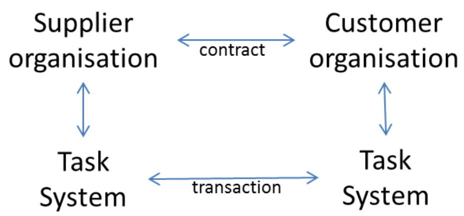

Figure 2: Organizations and Task systems

The word "organization" may be used to mean a process of organizing, but it is used here to refer to the supplier or customer itself [101]. For example, the orthotics supplier is an organization, although the orthotics supplier also has a particular way of organizing its task systems in supplying orthoses.

Before describing a supplier's relation to its indirect customers' contexts-of-use, the dynamic alignment of the behavior of the supplier's task systems can be described to changing and/or heterogeneous forms of direct demand as follows:

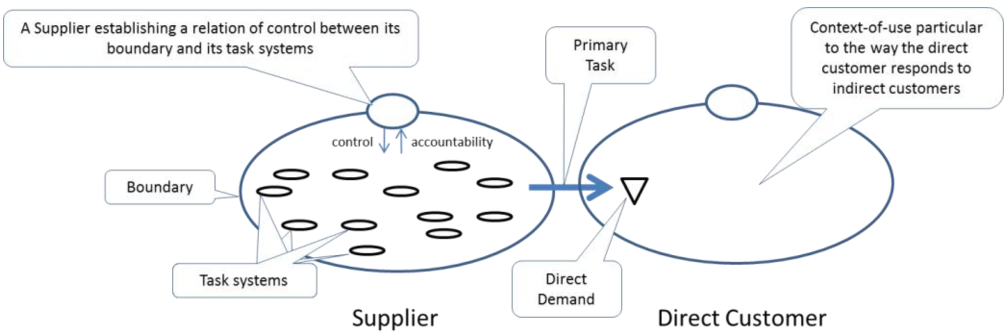

Figure 3: The relationship between supplier and direct customer

- A supplier is defined as an organization containing one or more task systems around which the supplier can place a boundary. These task systems interact with each other through transactions and enable the supplier to satisfy direct demands [99].
- The relationship between the supplier and its task systems is one of control (and one of accountability in the reverse direction). The relationship between a supplier and its direct customers is one of exchange in which particular products or services are provided in return for some form of compensation [99].
- The primary task for a supplier is that task which its organization determines must be performed if it is to survive as an operationally and managerially independent

entity. The primary task is therefore the relationship that a supplier must sustain with its customers if it is to remain viable [100].

- A context-of-use is the particular environment defined by the direct customer within which a direct product or service provided by a supplier is used by a direct customer as a part of how that customer responds to the demands of that customer's customers (the supplier's indirect customers, for example [102]).
- A supplier may have to engage in a number of primary tasks depending on the direct customer relationship, qualifying primary task in terms of primary risk: the risk that the primary task it has chosen to realize the particular customer relationship will not meet the interests of its stakeholders [103].

A supplier will have its own interpretation of what is in its stakeholders' interests. This interpretation can be thought of as the supplier's model, more or less explicit, organizing the critical relationships through which it must realize those interests. The individuals in roles defined by the organization constitute a sentient system, being a social system exchanging meaning and purpose with each other under the constraints imposed by the organization. The supplier's model will therefore be built partly into the way its task systems are structured, and partly into the way its sentient system directs and constrains the use of those task systems in the interests of its stakeholders. The supplier's model is realized through the behavior of the supplier's task systems.

- This model constitutes the identity of the supplier, but is identified with the task systems over which the supplier has direct control, the boundary of these task systems marking the limits of this control.
- Key task systems that are critical to how the supplier realizes its identity may be bound to it contractually, rather than being directly under its control. The supplier may therefore identify itself in terms of a perimeter including what is within its boundary, but extending to include what falls under its contractual control.
- A supplier that forms temporary organizations of particular task systems to align them to particular customers' demands need have no boundary if all its task systems are contracted in; and its perimeter need only be defined in terms of an edge relative to the customer relationship determining the way it meets that customer's particular demand.

Whether defined in terms of boundary, perimeter or edge, a supplier is engaged in a domain of interactions within which it is trying to sustain its identity. This domain is constrained by what its stakeholders value in the way it defines its identity, and by what the stakeholders value in its exchange relationships with other suppliers and customers. With a for-profit supplier, this domain of interactions would be the domain in which it was pursuing sustainable competitive advantage [104], but for the not-for-profit supplier, this domain would be the one in which it sought to be generative in how it created value for its beneficiaries [105]. And for the publicly owned supplier, this domain would be the one in which it was expected to generate public value [106]. In each case, what the stakeholders valued would affect how the supplier identified itself with boundary, perimeter or edge.

Pursuing a sustainable identity through creating economies of alignment

The conventional approach by which a supplier creates a sustainable identity for itself has been in terms of creating sustainable competitive advantage with the resources under its control, i.e. within its boundary or perimeter [107]. For example, the orthotics clinic was competing with other forms of treatment provided by other clinical specialisms, and to survive had to secure funding for its services.

A supplier will face a variety of demands from its direct customers. The challenge is to be able to judge what kinds of response to this variety will create the greatest competitive advantage. Under stable conditions of direct demand defining its market(s), a supplier can define its primary task in terms of securing economies of scale and/or scope within those markets. If these economies are superior to those offered by its competitors, it provides the supplier with an opportunity for sustainable competitive advantage if that superiority can be maintained [108]. Following Porter [109], competitive advantage is based on owning something that others want, i.e. on establishing property rights, in terms of which it is possible to describe the competitive advantage of the clinic as the intrinsic value of the knowledge its clinicians practice. In these terms, the value of the clinic is its ability to displace others' treatments with its own more effective and/or more economic treatments.

Under changing conditions, markets disaggregate as industry boundaries dissolve – they become 'unstructured' in that the rules of competition become increasingly open to change [110]. As a consequence, the supplier's competitive strategy also becomes a matter of disrupting competitors' competitive advantage based on innovation, agility, and being able to compete on multiple dimensions simultaneously [111]. With this comes a need to shift the supplier's locus of innovation from supply to demand [112], so that in the place of markets comes a focus on the particular demands of direct and indirect customers within their contexts-of-use [113]. This focus demands that the supplier places greater emphasis on the ability to create new organization in order to create new business propositions, adopting 'shaping strategies' [10] that focus on ecosystems in which networks of businesses become the new economic 'entity' shaping competition [114]. This in turn means that the economic focus of the supplier has to go beyond the scale and scope economics of its own 'transactions' to consider the economics of the forms of governance aligning these business networks to new forms of indirect demand arising within customers' contexts of use [115].

This gives rise to the emergence of 'relationship economics' organized around the particular indirect demand [8], and an increasing focus on creating value for the indirect customer [116] in which it becomes essential for the supplier to develop capabilities for dynamic specialization, connectivity and leveraging capability-building across institutional boundaries [117]. Creating this indirect value involves enabling available products and services to be aligned to the particular needs of the indirect customer. Thus in the case of the orthotics clinic, becoming more efficient and cost effective in the delivery of treatments was a necessary but not sufficient condition. The quality of its service also depended on being able to deliver over time exactly those changes in treatment that a patient's condition warranted. This involved going beyond the forms of direct value created in delivering treatments, and giving consideration to the indirect value its behaviors made possible within the larger ecosystem, in this case through the longer term impact its treatments had on the patient's condition and on the quality of the patient's life. In the case of the UAS supplier, it meant adding capabilities to its systems than enabled it to be used in support of wider varieties of interoperation at greater tempos responding to increasingly complex forms of mission.

Distinguishing the different forms of competitive advantage

The supplier can define these more dynamic forms of competitive advantage in terms of asymmetries of know-how, based on knowing something that competitors don't know that creates value for its customers. Three kinds of asymmetric advantage can be distinguished in terms of three different types of know-how [112], the third of which addresses indirect demands:

1. Know-how of the uses of technology by socio-technical systems, in which the relationship to the direct customer is defined in terms of the ability to manage a primary task on which the survival of the supplier depends [100]. For example, the orthotics supplier knows how to make orthoses.
2. Know-how of the customization of business processes to deliver particular solutions to direct customers within different contexts-of-use, in which the relationship to the customer is defined in terms of the ability to manage primary risk on behalf of the direct customer in selecting the right combination of tasks and solutions [103]. For example, the clinician knows how to customize the use of particular orthoses to the needs of a particular treatment.
3. Know-how of the alignment of products and solutions to the indirect customer's experience over time within the particular indirect customer's context-of-use. It is this third kind of asymmetric advantage that depends on understanding the direct customer's particular way of organizing their response to indirect customer situations, creating indirect demands on the supplier. For example, the clinician knows how to manage the patient's treatment within the context of the patient's developing condition through its life.

A different kind of supplier approach to defining value goes with each of these:

1. Superior know-how about the uses of technology generates economies of scale – the ability to produce products and services at lower cost than competitors;
2. Superior know-how about customization of business processes generates economies of scope – the ability to deliver solutions to different customers and markets at lower cost than competitors; and
3. Superior know-how about embedding and sustaining solutions that can remain dynamically aligned over time to an indirect customer's context-of-use, generating economies of alignment for both the direct and indirect customer. These economies reduce the costs to them both of orchestrating and synchronizing the way solutions are used within indirect customers' changing contexts-of-use.

Despite continuing appeals for improved quality of service [5], the project examining the quality of care provided by UK National Health Service Orthotic Clinics showed how existing approaches to these clinics emphasized the first two of these forms of advantage while ignoring the third, leading to the systematic under-use of such treatments in chronic conditions [4]. And despite having identified significantly greater through-life costs for both the patients and the NHS arising from this under-use, the identities of the clinics remained unchanged as a result of the way other suppliers within the larger ecosystem in which they were embedded conserved their identities [97]. Equally, the costs of making effective use of tactical sensor capabilities falling within the potential capabilities of UASs cost as much as the development of the actual UASs, because acquisition of the UAS was focused solely on acquiring the direct capability, and not on its capability as a platform for supporting indirect demands for mission capability [3].

The different nature of the third asymmetry is summarized in Figure 4. The vertical axis describes whether or not a supplier can create economies of scale and scope through its ability to sustain the asymmetries of the first and second kinds. If it can, then it will be able to pursue a market -based strategy. Over time, any such position will be prone to increasingly globalized competition [118], pushing the supplier into the top opportunistic space in which it will become dependent on an opportunistic approach using marginal costing and pursuing incremental opportunities. What the third asymmetry introduces is the opportunity to pursue an approach that can produce effects on the indirect customers' demands ('effects-based').

An important background influence here is the impact of digitalization, altering the ways in which it is possible to create economies of alignment associated with the third asymmetry. Thus while digitalization accelerates the impact of globalization of competition on the first two asymmetries, thus reducing profit margins, "technology now makes it possible to demand that products and solutions be customized, personalized, unique and distinctive to ourselves within our context" [119], increasing the opportunities for creating economies of alignment for indirect customers, and therefore for suppliers to increase the opportunities available from managing the third asymmetry.

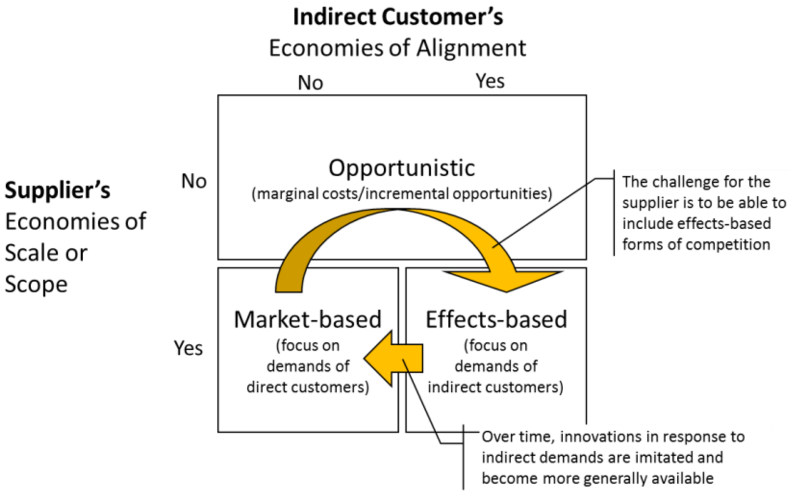

Figure 4: The supplier's relation to the customer's demand

Indirect demand and the third asymmetry

These forms of competitive advantage are not mutually exclusive. However, the difficulties in taking up the third type of competitive advantage derive from the relationship to indirect demands that it involves. Thus for generating economies of scale and scope, the supplier is only interested in those aspects of the direct customer's demand that can be abstracted and generalized across different direct customers' contexts-of-use, since this is how the supplier defines its markets. It can then treat the direct customer's demand as symmetric with its supply-side capabilities, and define its strategy as one of extracting maximum value from its existing supply-side position, the defensibility of which depends on its being able to maintain its first and second asymmetries with its competitors. This Nokia, the orthotic clinic and the UAS supplier were all doing.

With the third asymmetry, however, the supplier is interested in those aspects of the indirect customer's demand that are particular to their context-of-use over time, and thus cannot be abstracted and generalized in the same way. The supplier must therefore expect the indirect customer's demand to be asymmetric with any existing supply-side capabilities that it has, and its strategy must now be one of extracting maximum value from the ways in which it can create indirect value for its indirect customers through the way it supports both the direct and indirect customer's orchestrating and aligning of solutions to the indirect customer's particular changing needs, the defensibility of which depends on the quality of its relationship with both direct and indirect customers. An asymmetric demand is therefore an indirect demand which is specific to the indirect customer's particular situation and context-of-use, and which may include tacit or latent demand that the indirect customer is not yet able to articulate.

In a world of commoditization of existing products and services, the dominant source of opportunity shifts from creating supply-side asymmetries with competitors to reducing demand-side asymmetries with customers. The challenge for suppliers in satisfying these asymmetric forms of demand is in empowering and enabling individuals at the edges of their organization who directly experience an indirect customer situation to be able to organize appropriate responses to the particular nature of the indirect customer's demands [120]. Examples of individuals facing this kind of challenge are service engineers, the UAS operators in theatre, doctors in general practice, and the orthotists in our example. But the sustainability of satisfying asymmetric demands depends ultimately on the economic question of whether the value that can be captured by the supplier justifies the investment in reducing the indirect customer's costs of alignment. This in turn depends on being able to model the effects of any investment within the larger ecosystem including both direct and indirect customers.

Creating value in Ecosystems

A socio-technical ecosystem is a community of managerially and operationally independent organizations interacting with each other and with their environment. For example, the orthotics clinic was operating independently within the context of a healthcare ecosystem composed of primary and secondary care organizations supported by a whole menagerie of suppliers supporting a wide variety of patients and conditions. And the UASs were being provided by the supplier to the Royal Artillery customer that was itself providing an operational service within theatre to a land component commander, who was expecting the UAS to inter-operate with other military capabilities within the defence ecosystem to satisfy the demands of particular missions.

The complex networks of relationship within these ecosystems differ from the traditional "closed-world" relationships between a single supplier and its markets, in which the markets have attributed to them an existence independent of the customer contexts giving rise to the demands they represent. This "closed-world" view based on the single supplier is characteristic of the early work on socio-technical systems [100], in which the sustainability of the supplier's identity is dependent on its engaging in its primary task, defined in terms of a particular relationship to its market environment.

Defining this relationship becomes increasingly difficult as the turbulence of a supplier's environment increases [121]. Thus from a distance, it looks as if the orthotics clinic was delivering orthoses into a market for orthotic treatments defined by direct demands for orthoses. And for the routine supply of the plaster casts demanded by an orthopedic practice, this may be an adequate simplifying assumption. But many of the patients of the clinic presented indirect demands: they needed combinations of treatments that were unique to their condition as it unfolded within the context of their lives. The turbulence that the variety of these indirect demands created for the clinic is characteristic of ecosystems, in which the variety of indirect demands arises from the large numbers of indirect relationships between managerially and operationally independent entities that are constantly evolving and have no centralized control. These independent entities themselves have many heterogeneous elements, and collectively they give rise to demands that are inherently conflicting and unknowable [122].

A number of key drivers impact on the ability of a supplier to sustain its identity within such ecosystems, challenging the former "closed-world" perspective. Amongst these drivers are the tempo at which the ecosystems are themselves expected to evolve in response to changing demands from indirect customers' contexts-of-use, the ubiquity and criticality of the technologies on which they depend, and the entanglements not only between technology systems and the way they are used, but also between interoperating technology systems that are themselves managerially and operationally independent of each other [123]. It is the tempo of variation in the forms of indirect demand emerging from these contexts-of-use that makes the supplier's experience of its environment turbulent.

Modeling asymmetries

The Sovereignty of suppliers

The sovereignty of a supplier over its identity is defined as the ability of its stakeholder system unilaterally to impose and sustain its identification with a particular organization of its sentient and task systems. Sovereignty is thus reflected in the way the supplier distinguishes its boundary or perimeter.

A supplier choosing to support the direct demands of its customers can do so without any loss of sovereignty. But consider an indirect demand associated with an indirect customer situation, involving a collaboration between indirect customers, a direct customer and other suppliers. Assume that this collaboration will be supported by an orchestration of the customized behaviors of the various suppliers' and customers' task systems, synchronized by the sentient system identified with the collaboration. This collaboration will itself be a socio-technical system capable of aligning the behaviors of the collaboration with the value system associated with the stakeholders in the indirect customer situation.

The orchestration of systems supporting any such collaboration will be a system of systems (SoS), being composed from the task systems of suppliers and customers that are operationally and managerially independent of each other [124]. This orchestration may have been defined prior to the collaboration (at a 'design-time'):

- Directed: The constituent systems are subordinated to the SoS objectives, management, funding and authority. For example, a hospital patient information system.
- Acknowledged: The SoS has its central objectives, management, funding and authority, but the constituent systems retain their own independent management,

funding and authority. For example, the SoS enabling hospitals, primary care physicians and service providers to exchange information.

Alternatively, the orchestration may be being defined at 'run-time' by the collaboration itself, producing two further types of system of system as follows:

- Collaborative: There are no central objectives, management, funding or authority, and constituent systems voluntarily work together within collaborations to address shared or common interests. For example, patient healthcare records assembled by patients from registered sources on the internet.
- Virtual: Virtual systems-of-systems are like collaborative systems-of-systems, except that the constituent systems do not know about each other. For example, the community of research collaborations investigating healthcare outcomes for diabetes.

This generates four types of system-of-system [125]. The variety of orchestrations for the first two types of SoS can be defined at design time by the direct customer (or the supplier acting on behalf of the direct customer), enabling a single authority to define the variety of primary risks to be supported by the orchestration. But with the second two types of SoS defined at run-time, each orchestration is under the control either of the particular indirect customers defining its use, or of the collaboration supporting those indirect customers, making the variety of primary risks to be managed open-ended [126].

The challenge for the supplier under these conditions is therefore to develop an ecosystem platform architecture that is sufficiently agile to respond to the open-ended variety of indirect demands that it is expected to support [127]. Unlike a directed or acknowledged SoS, in which its suppliers that can remain sovereign within their boundary or perimeter, the suppliers of a collaborative or virtual SoS cannot remain sovereign because of this open-ended variety, surrendering sovereignty to the collaborations supporting their indirect customers in order to enable the customers' values to constrain the behaviors of the platform architecture in support of their collaborations.

As a result, a supplier choosing to support an open-ended variety of indirect demands from its indirect customers will have had to extend its stakeholder system, surrendering elements of its sovereignty across multiple edges. Any modeling of such a supplier will therefore need not only to represent the role taken by its sentient system, but also the variation in the values of its customer stakeholders across the edges that its task and sentient systems will need to support. This was the case for the iPhone users, raising questions of how the platform constrained the use of suppliers' applications; for the UAS supplier, affecting what forms of mission environment it would support; and for the orthotics clinics, determining the extent to which patients' through-life conditions could be supported.

Modeling the identity of a supplier across three levels of openness

An open-ended variety of primary risks that the supplier might choose to support involves the supplier's model being open at three levels:

- At the level of its observed behavior in the way it engages in material exchange with its environment.
- At the level of the selection of the constraints determining its observed behavior, changing the way it interacts with its environment at the observed level [128].

- At the level of the value its stakeholders attach to the way it selects models determining the way it interacts with its environment.

The observed behavior of a supplier can be modeled in order to define its behavioral closure, defined as all the possible sequences of behavior of which it is capable. The three levels of openness can then be defined by three different orders of behavioral closure, each being predicated on its lower orders of closure being non-deterministic.

First-order behavioral closure

A supplier's model of the behavior of its task systems is expressed in terms of a state space, in which the task system's behavior may be represented together with a set of events to which it responds, the states in which it may find itself initially, and the relations that identify the state transitions provoked by any given event.

- The first order behavioral closure of such a model is the set of all paths through state space along which the task system may travel, representing its possible behaviors.
- If the states of these modeled behaviors can be placed in some form of commutative relationship with the observed behaviors of the task system, then the behaviors of that task system are simulable.
- The model of the behaviors of the task system is open at this first level if the first order behavioral closure of its state space includes events in its environment.
- This model is non-deterministic if, for a given state and a given event, there may be more than one state to which it may go.
- Task system behavior that can be modeled by a deterministic first-order behavioral closure is structure-determined.
- Finally, while the inferential entailments of the supplier's model of the behavior of its task system are expected to commute with the causal entailments in the observed behavior of the task system, the business model is itself incommensurable with those observed behaviors: the observed behaviors cannot be reduced to the model itself.

Second-order behavioral closure

To the extent that the supplier's model of the behaviors of its task system is non-deterministic, the sentient system of a supplier is constituted by those people determining its modal constraints. These are constraints such as liveness (the property that the business model's behavior eventually reaches some desirable state) and safety (the property that the business model's behavior never reaches some undesirable state). The modal constraints enable the sentient system to ensure that some states are necessarily, possibly or never reachable when they are applied to the model of the behavior of the task system; and they may be satisfied through their being applied directly to this model, or through controlling parameters to certain aspects of this model's behavior. Either way, each possible set of constraints on the business model comprises a point in a model space.

This model space is a space in which each point represents a deterministic first-order behavioral closure of the behavior of the model of the task system's behavior, with the dimensions of the model space being the parameters defining the different dimensions of constraint placed on it by the sentient system. Trajectories through the model space represent changes in the way the (model of the behavior of the) task system is allowed by the sentient system to interact with its environment, reflecting changes in the way the sentient system places constraints on it.

- The sets of constraints on the task system model, represented by a trajectory in model space, are structure-determining of a non-deterministic first-order behavioral closure insofar as they constrain the behavior of the task system model to be deterministic.
- The set of these trajectories is a second-order behavioral closure, being the trajectories in model space that the sentient system allows for the task system model.
- A second-order behavioral closure is deterministic if there is only one trajectory through model space for each initial model, otherwise it is non-deterministic.
- A second-order behavioral closure that is non-deterministic is open at a second level of openness.
- A sentient system that generates a deterministic second-order behavioral closure can be accounted for by the first-order behavioral closure of the model of a task system that has had its state space and input conditions enlarged.

Thus when a supplier appears to change the way it interacts with its environment, it may be possible to increase the detail and scope of its task system model in order to explain such changes through including greater numbers of feedback mechanisms between the supplier and its environment. Under such circumstances, software can be used to replace the deterministic aspects of the sentient system's constraining of the non-determinism of its task system model. In order to distinguish a sentient system from a task system, therefore, the definition of a sentient system is restricted to those aspects of its constraining that are non-deterministic, and therefore open. This creates a second incommensurability between the open sentient system and the task system model: the sentient system cannot be reduced to a task system model.

Third-order behavioral closure

The stakeholder system of a supplier is constituted by those people with the power to determine what trajectories through the model space are of value. Every point in the model space determined by the supplier's sentient system will also be experienced by the stakeholder system as being of some value from the point of view of the way the supplier supports its stakeholders' identities. A value space can therefore be defined in terms of a model of the stakeholder system's dimensions of value, such that each point on a trajectory in model space that is valued becomes a point in value space. The value space of a supplier makes the supplier anticipatory [129], its choices of trajectory being based on the way its stakeholders anticipate the value of its behaviors with respect to a changing environment [130].

- Trajectories through the value space therefore represent further constraints on the way a task system may interact with its environment.
- These trajectories model what trajectories are of value to the stakeholder system, defining a third-order behavioral closure reflecting the interests of the supplier.

- This third-order behavioral closure is deterministic if there is only one trajectory through value space for each initial model, and is open if the behavioral closure is non-deterministic.

Where the third-order behavioral closure is deterministic, the values of the stakeholders can be reduced to an elaboration of constraints in the model space. In order to distinguish a stakeholder system from a sentient system, its definition is therefore restricted to those aspects of its constraining that are non-deterministic and therefore open. This creates a third incommensurability between the sentient system's modal constraints and the stakeholder system's value constraints: the stakeholder system cannot be reduced to a sentient system. The modal constraints are <u>object-referenced</u>, being expressed purely in terms of the task system's state space, and make no reference to the values attributed to the stakeholder system; while the value constraints are <u>subject-referenced</u>, being referenced solely to the valuations of the members of the stakeholder system.

Triply-articulated modeling of a supplier

Modeling a supplier across three levels of openness must be able to reflect its relationships to both direct and indirect forms of demand within the ecosystem forming its environment. Modeling the way the supplier supports its identity must therefore distinguish primary task and primary risk within a domain of interactions valued by both its own stakeholders and the stakeholders in the customer situations it supports. Taking the orthotics case for example, on the supply-side are the task systems associated with making and supplying orthoses, while on the demand-side are the patients' conditions within the contexts of the patients' lives, and the composite treatments aligned by the clinician over time to those conditions. The domain of interactions is therefore everything to do with both the supply and the use of orthoses. The primary task of interest here is to provide orthoses in ways that satisfy the demands of patients; and the primary risk is that this should be done in a way that is appropriate to the individual patient's condition, while also being economically sustainable. If no value is attributed to meeting patients' indirect demands, this reduces to meeting only the direct demands for orthoses, the primary risk being that orthotics suppliers should fail to pursue the supply-side profitability of its primary task through giving excessive priority to patients' long-term interests.

Thus while the three incommensurabilities distinguishing the three levels of behavioral closure are independent of each other, the particular way in which they are held by the supplier in relation to each other reflects its particular way of supporting its identity within a domain of interactions relevant to those behaviors valued by its stakeholder system. This particular way in which the three incommensurabilities are held can be described in terms of the quadrants in Figure 5, representing four different aspects of the way the supplier supports its identity:

- The 'what' – the task system behaviors of the supplier
- The 'how' – the model being used to control the behavior of its task systems
- The 'who-for-whom' – the way the sentient system of the supplier constrains the supply-side behavior of its task systems in support of particular customer situations
- The 'why' – the model of the value space shaping the customer situations.

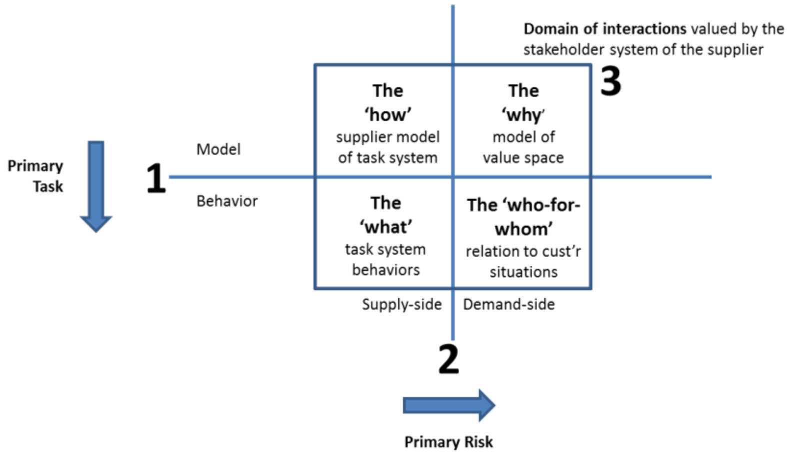

Figure 5: The three incommensurabilities describing the way the supplier supports its identity

A modeling approach that can distinguish the way in which these three incommensurabilities are created in relation to each other is referred to as a projective analysis, and must be a triply-articulated model of the supplier in order to capture all three incommensurabilities. The content of each quadrant defines the particular way the incommensurabilities are held in relation to each other (shown in Figure 5), but given the way the incommensurabilities are defined in terms of behavioral closures, these quadrants can also be represented as stratified layers creating a stratification as shown in Figure 6, with each layer forming the context within which the layer below it is managed. These stratified layers localize the incommensurabilities as asymmetries corresponding to the different types of competitive advantage. Thus economies of scale derive from the way the supplier model manages particular task system behaviors, economies of scope derive from the way task system behaviors are constrained in relation to different types of customer situation, and economies of alignment derive from the way support to customer situations are aligned to the values shaping the customer situation other than those of the supplier.

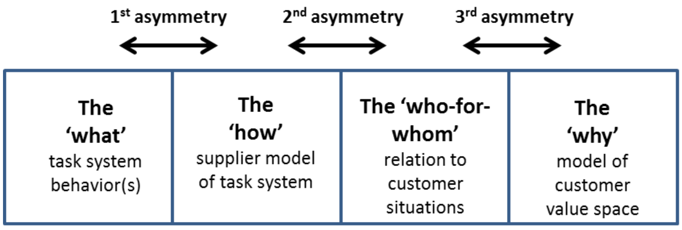

Figure 6: Mapping the incommensurabilities to the asymmetries

Value Stratification

Stratification as representing the relation to indirect demand

A supplier supporting the demands of indirect customers' needs to be able to support a variety of different orchestrations of its own and others' products and services within a given timeframe of response. This involves being able to relate these varieties of orchestration across the three different asymmetries shown in Figure 6 that together stratify the way supply is aligned to indirect demand. But each asymmetry has its own timeframe of response [91]:

- Indirect customer situations that determine the different ways in which collaborations are needed to generate effects on indirect demands arising at an (indirect demand tempo*).* The expectation is that new forms of collaboration are needed continuously with their associated costs of alignment.

- Orchestrations determining the ways in which interactions between customers and suppliers can be supported if effects are to be generated in indirect demand situations, the (orchestration tempo) being the tempo at which new types of orchestration can be created.
- Systems determining the way behaviors can be generated becoming available at an (acquisition and supply tempo), within which a technological capability for a new type of behavior can be acquired, made ready for use, and sustained.

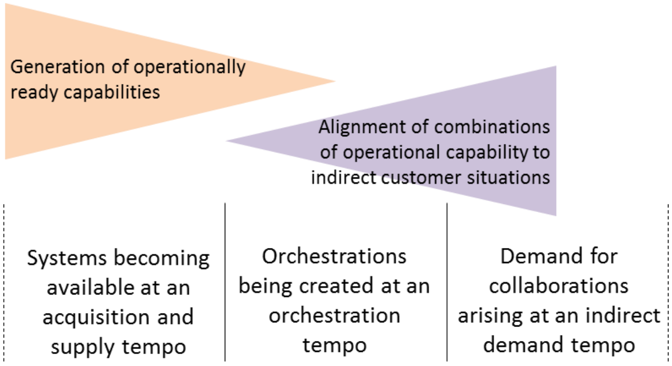

Figure 7: The tempos associated with the different asymmetries

Thus acquisition and supply agility can accelerate the generation of new types of behavior by suppliers, while orchestration agility can multiply the variety of ways in which orchestrations can be formed, available to collaborations synchronizing their behavior with indirect demands emerging at an indirect demand tempo. Where the acquisition and supply tempo is slower than the indirect demand tempo, it is economically not possible to create a new supplier for every newly emerging indirect demand, so that the agility of the platform architecture supporting the orchestration of existing suppliers has to bridge between the two. In the smartphone ecosystem, orchestration tempo depended on the accessibility and effectiveness of integrating new applications with indirect customers' existing uses, such as in the integration of location-based services. In the UAS ecosystem, orchestration tempo depended on the speed and ease of integration with other operational capabilities in theatre, such as people on the ground and fast jets. And with the orthoses, orchestration tempo depended on the ways in which it was possible to manage complementary clinical authorities over the ongoing treatment of the patient's condition, such as physiotherapy and orthopedics.

To architect agility, there has therefore to be an ability to manage variation across the different levels of the stratification:

- Acquisition and Supply tempo generates the need for variation in how suppliers provide solutions for their direct customers giving rise to product-line practices based on the variety of markets their direct customers are in (for example different versions of Nokia mobile cellular phones [131]). This may go as far as enabling direct customers to vary the indirect customer situations they can support through providing parameters enabling the behavior of an installed system to be varied at its time of use i.e. customized. Here 'design-time' product-line practices have to be extended to include run-time parameterization (for example in providing a real-time software framework that can integrate current and future competitors' products [132]).

- Orchestration tempo generates the need for variation in how indirect customer situations can be supported by collaborations bringing together different combinations of suppliers' services at 'run-time' (for example supporting different patterns of energy generation for households with a smart grid ecosystem [133], or by supporting the combination of different kinds of location-based application for iPhone users [134]). It is the variation in the 'run-time' support needed by the varying collaborations demanded by these indirect customer situations that creates the need for platform architectures that can support tempos.

Modeling architectures that can support orchestration tempo

The two triangles in Figure 7 span the different asymmetries, the left-hand (supply-side) triangle focused on the first two asymmetries generating operationally ready capabilities responding to direct demands. These asymmetries can be managed by a sovereign supplier, so although the values of its stakeholders are subject-referenced, the behavior of the supplier can be wholly object- referenced under that sovereignty. The right-hand (demand-side) triangle, however, is focused on the second and third asymmetries of dynamically orchestrating and synchronizing combinations of capability in response to the indirect demands arising within indirect customer situations. In these situations there has to be some surrender of sovereignty to the subject-referenced values of the stakeholders in any given customer situation, so that while the processes of alignment may be object-referenced, the articulation of the values shaping the customer situations must be explicitly subject-referenced. For the supplier to evaluate the indirect as well as the direct value of any changes, the costs of both triangles then have to be identified [92], combining the activity-based costs of using the operational capabilities with the costs of aligning the use of multiple such capabilities to each other within any given indirect customer situation.

The agility in how the left-hand and right-hand supply-side and demand-side triangles may respond to different types of indirect demands has direct architectural consequences for the software systems supporting it [135]. But to understand the potential indirect value of agility to the supplier, we need to understand the relation of such systems to the demand-side organization making use of them.

To do this, the different layers in Figure 7 have to be modeled in such a way as to be able to draw architectural implications not just for the relationships within each layer, but across all the layers. This is done by representing the architecture of each layer by splitting it into two, separating behavior from the structuring effects of its architecture:

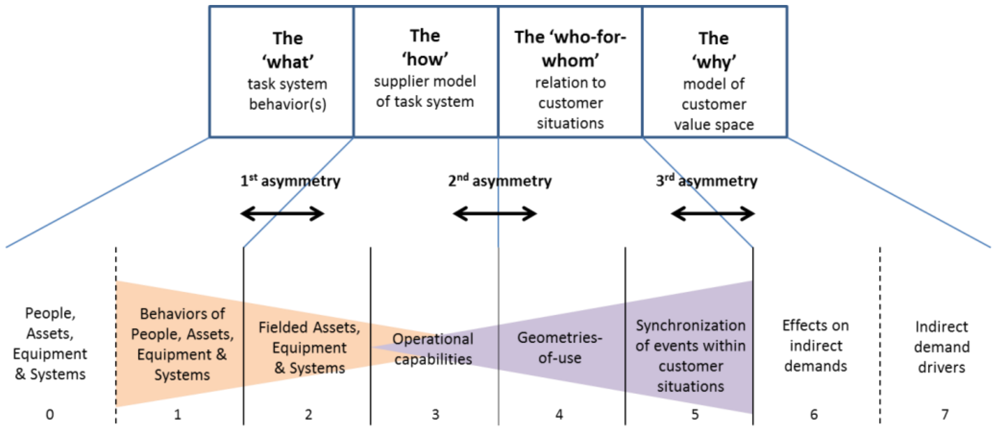

Figure 8: The stratification layers representing architecture within each quadrant

This layering represents a stratification that can dynamically align the underlying supply-side behaviors of people, assets, equipment and systems to produce demand-side effects within the context of indirect demands. This stratification therefore relates object-referenced knowledge of behaviors to the subject-referenced knowledge of values determining the way those behaviors are aligned to indirect customer situations. The more variation there is in these indirect demands, the more variation has to be possible in the relationships between the layers, making the tempos of variation possible within and across the different layers crucial. The task is therefore to establish how an ecosystem platform architecture can hold these layers dynamically in relation to each other in order to architect agility, to establish what forms of value are created as a result, and to identify the risks to creating this value. The aim of projective analysis is to model these layers and the possible relationships between them, in order to describe how the supply-side and the demand-side can be related to each other. Chapter 4 will describe how this modeling is done, and Chapter 5 will describe their practical application. But how are the relationships between these layers to be analyzed?

Modeling asymmetries as structural 'gaps'

Layer '0' represents 'actual' structures defined by people, assets, equipment and systems of a supplier's task system, and layer '1' represents their observed behaviors. These structures are represented in Figure 9 as simplices, with the potential behaviors of each one represented by the set of *vertices* in each row. The simplicial complex is the set of all the simplices defining all the potential behaviors of the supplier's task system, in which vertices shared by more than one simplex represent the ability for the behavior of those overlapping simplices to be coordinated directly with each other through their interaction in the overlap. The simplicial complex itself might represent the manufacturing capabilities of an orthotics provider, and the overlaps might be from the way the inputs and outputs of its processes were linked.

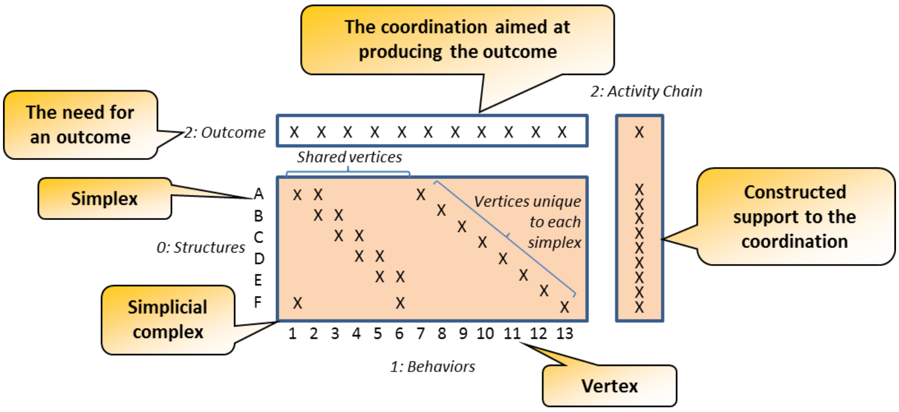

Figure 9: The support to a coordination spanning the first asymmetry

Consider the supplier's need for a model of the behavior of its task system, aimed at managing how to produce a particular outcome to be supplied under a particular contract, requiring the coordination of actual behaviors in its task system, for example to provide bespoke orthoses ordered by a particular clinic. No such coordination is possible directly in the 'actual' behavior of the task system itself, since no single structure generates this behavior. This necessitates a model of the task system that can be used to control the behavior of the relevant individual structures within the task system, creating an activity chain in layer '2' that will produce the outcome needed in layer '3'.

The asymmetry between the 'actual' behaviors of the task system in layers 0 & 1 (represented by the simplicial complex) and the model of the task system in layers 2 & 3 make this constructed support to the coordination a constructed 'object' within the model of the task system that bridges a structural 'gap' in the coordinations of behavior possible within the 'actual' behaviors of the task system itself. The effects of this asymmetry can be described in terms of four characteristics, shown in Figure 10:

- A need, taking the form of a demand for an outcome to supply a particular contract.
- The aim of a coordination of behaviors intended to generate that outcome.
- A 'gap', being a structural hole in the behaviors of the task system itself.
- An 'object', being the constructed support to the coordination needed to bridge the structural 'gap'.

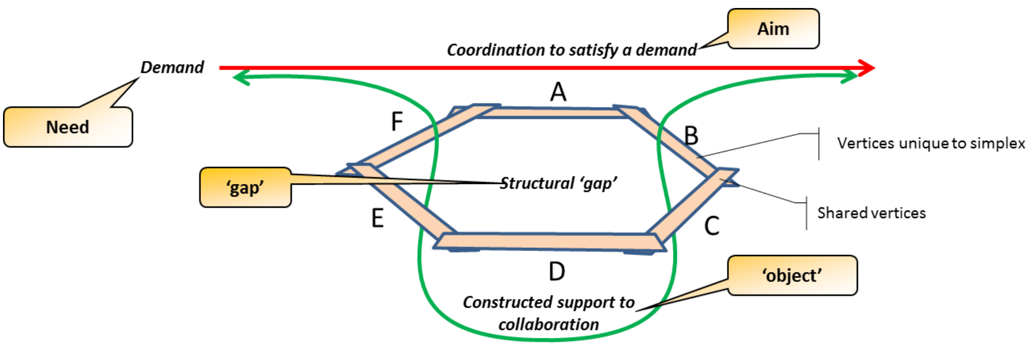

Figure 10: Defining a structural 'gap' in a task system

This pattern then repeats itself in Figure 11 across the second asymmetry, in which the models of suppliers' task systems are defined by the simplicial complexes of layer '2' outcomes (simplices) supporting potential layer '3' supply contracts (vertices) they can enter into as defined by their own sentient systems constrained by their stakeholder systems (for example, the contracts possible with a bespoke orthosis manufacturer and a ready-made orthosis supplier). Vertices shared by more than one simplex here represent the ability of the sentient systems of those overlapping outcomes to coordinate with each other through the contracts they participate in directly.

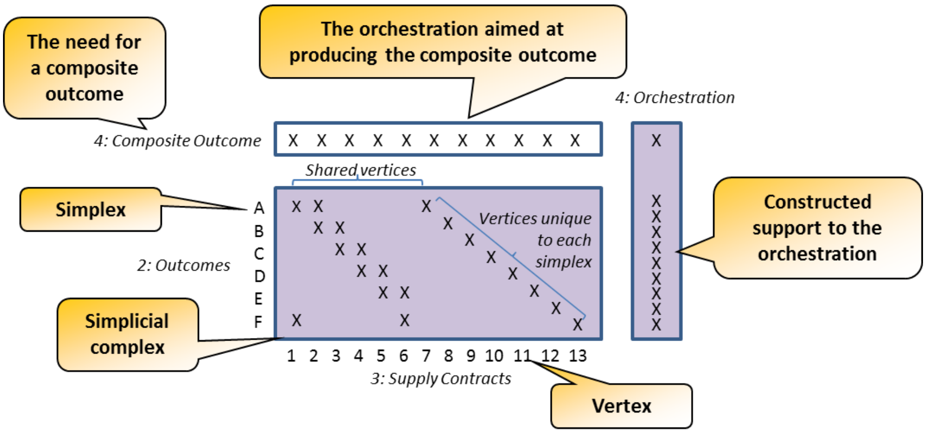

Figure 11: The support to an orchestration spanning the second asymmetry

The direct customer's need is for a level '4' orchestration to support its own level '5' synchronization of events, which brings together a number of suppliers' contracts aimed at a producing a particular composite outcome that cannot be directly coordinated between the suppliers' sentient systems. This necessitates the sentient system of the direct customer (or of a supplier acting on the customer's behalf) constructing a layer '4' support to the orchestration needed in the form of an orchestration of suppliers' customized outcomes, in this case spanning an asymmetry between the sentient system of the direct customer (or of a supplier acting on the customer's behalf) and the suppliers' sentient systems. For example, the clinician working within the clinic must bring together a number of products and services from suppliers in order to be able to provide the patient with a particular treatment. From the perspective of the supplier, these describe multi-sided demands described in Appendix A, p77, representations of which are described in more detail in Appendix B, p81.

Finally, Figure 12 shows the spanning of the third asymmetry. The simplicial complex shows the level '5' synchronization events (for example clinic treatment episodes) that can be supported by the level '4' composite outcomes provided by different direct customers' sentient systems (or by suppliers acting on behalf of their direct customers), for example providing a number of different episodes of care to the patient. Vertices shared by more than one simplex here represent the ability of those overlapping composite outcomes to be synchronized directly with each other in response to the indirect customer's demands through the overlap, for example through the way the episodes can be linked within a care pathway. These are the effects ladders also described in Appendix B, p81.

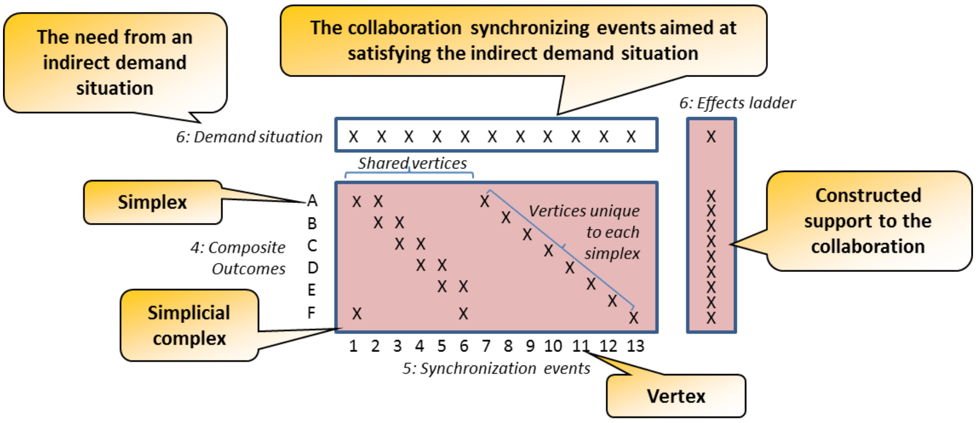

Figure 12: The support to a collaboration spanning the third asymmetry

The indirect customer's need in the indirect demand situation (for example defined in terms of the impact of their chronic condition on their life) is for a collaboration synchronizing events (for example treatment episodes) aimed at satisfying the level '7' drivers behind its level '6' indirect demand. This requires that the collaboration construct support synchronizing events spanning a number of composite outcomes that cannot be directly synchronized, involving the value system of the indirect customer (or the direct customer on the indirect customer's behalf) constructing a layer '6' collaboration constraining the way the composite outcomes are synchronized. (In the UAS example, the interdiction of a fleeting target is a level '5' synchronization event, and this level '6' of organization corresponds to the campaign plan within which the interdiction plays its part, designed to produce its effects in level '7'.)

Conclusions

A supplier must choose to surrender elements of its sovereignty over object-referenced behaviors if it is to create indirect value for its indirect customers, experienced in terms of their subject-referenced values. The successive layers of the stratification in Figure 6, shown in Table 2, result from applying the four characteristics of an incommensurability to each of the resultant three asymmetries as they emerge between a supplier and its direct and indirect customers. Given that projective analysis provides a means of modeling the relationships within and between all these layers for a given ecosystem, it becomes possible to describe the stratification of the way suppliers' task systems are aligned to direct and indirect customers' demands, providing a template for identifying both activity-based costs and costs of alignment. Such a model also makes it possible to analyze the structural characteristics of the stratification in order to identify structural 'gaps' in its alignment processes, from which risks may be identified and mitigated. With such analyses it then becomes possible to manage the progressive evolution of a supplier's architecture in support of evolving indirect demands. Without such a method, a supplier has no systematic way of doing these things.

Table 2: the layers of stratification emerging from the three asymmetries

	Simplicial Complex: Simplices	Simplicial Complex: Vertices	collaboration 'object' spanning structural 'gap'	Aim of collaboration	Need creating demand for Aim
3rd asymmetry	4: composite outcomes	5: synchronization events	6: effects ladders	6: effects	7: drivers
	direct customer's sentient system			indirect customer's value system	
2nd asymmetry	2: outcomes	3: supply contracts	4: orchestrations (orchestrations)	4: composite outcomes	5: synchronization events
	supplier's business model			direct customer's sentient system	
1st asymmetry	0: structures	1: behaviors	2: activity chains	2: outcomes	3: supply contracts
	behavior of supplier's task system			supplier's business model	

Chapter 4 - Projective Analysis

Outline of Contents

- **Introduction** – the need to identify the risks associated with structural 'gaps'
- **Modeling three levels of openness** – defining the way each articulation is modeled, together with the relations between them, satisfying the requirement from Chapter 3
- **Implementing Projective Analysis** – the particular implementation and its methods of analysis
- **Conclusion** – the frame of reference meets the requirements from Chapter 3

Introduction

Projective analysis aims to provide a means of modeling the relationships within and between the stratified layers of an ecosystem in order to describe the way suppliers' task systems are aligned to direct and indirect customers' demands. This forms a basis for analyzing the structural characteristics of the relationships within and between these stratified layers in order to identify structural 'gaps' in their alignment processes. From these structural characteristics the risks of present alignments and proposed re-alignments may be derived together with costing templates for quantifying their costs and benefits. Such analyses enable the progressive evolution of a supplier's architecture to be managed in support of capturing the indirect value of emergent indirect demands, examples of which are outlined in Chapter 5.

Fundamental to the analysis of these structural characteristics are the risks associated with the way each layer in the stratification is aligned in support of the layers above it (shown in Table 3). Identifying these risks depend upon identifying the structural 'gaps' in the supporting layers, since these gaps represent potential errors in the way these 'gaps' are bridged by suppliers, giving rise to risks. Errors in Technology, Design and Construction are familiar to the supplier in the way it runs its business and correspond to the alignment of layers 0 to 3. However, the errors of execution, planning and intent are based on human errors [136] arising from the way the sentient systems of suppliers and their customers in layers 3 to 6 align products and services to the particular demands of indirect customers.

The aim of the analysis is therefore to establish a stratification of the ecosystem in relation to the indirect demands arising within it that are of interest to a particular supplier, to analyze the alignment between its layers, and then to identify risks and their mitigation through examining the potential for error in the way the layers are aligned. Four kinds of analysis can be based on this stratification:

- Dependency analysis between elements of suppliers' models of the 'actual' behavior of their task systems, describing the performance of their business models in producing outcomes.
- Risk analysis of the possible misalignment errors emerging between the layers of the stratification in responding to new forms of indirect demand.
- Economic analysis of the distribution of value across the layers, and of the impact of changes in the flexibility of task systems on the agility of the larger ecosystem.

- Architectural trade-off analysis of the way variation in indirect demands can be supported by different architectures of collaboration.

This section describes the modeling method needed to support these forms of analysis.

Table 3: Mapping the risks to stratification layers

	Simplicial Complex		collaboration 'object' spanning structural 'gap'	Aim of collaboration	Need creating demand for Aim
	Simplices	Vertices			
			Error of Intent: 5→6		
	Error of Planning: 4→5				
3rd asymmetry	4: composite outcomes	5: synchronization events	6: effects ladders	6: effects	7: drivers
	direct customer's sentient system			**indirect customer's value system**	
			Error of Execution: 3→4		
	Error in Construction: 2→3			**Error of Planning**: 4→5	
2nd asymmetry	2: outcomes	3: supply contracts	4: orchestrations (orchestrations)	4: composite outcomes	5: synchronization events
	supplier's business model			**direct customer's sentient system**	
			Error in Design: 1→2		
	Error in Technology: 0→1			**Error in Construction**: 2→3	
1st asymmetry	0: structures	1: behaviors	2: activity chains	2: outcomes	3: supply contracts
	behavior of supplier's task system			**supplier's business model**	

Modeling three levels of openness

The incommensurabilities between an organization's behaviors and its state, model and value spaces are identified with its task, sentient and stakeholder systems respectively. Describing the composite behavior of any given collaboration between suppliers and customers involves modeling the relationships between their separate task systems, sentient systems and stakeholders defining their respective perimeters and edges.

Modeling each level of openness as an articulation

In order to model this composite behavior within an ecosystem, the modeler therefore needs to be able to model the behavior of task systems and the constraints placed on these behaviors by sentient systems and stakeholder systems separately, as well as modeling the relations between them. Thus,

- Let the state space modeling the behavior of task systems be defined by processes punctuated by events, these related processes and events being collectively referred to as a behavioral articulation represented by the symbol $'\mathbb{B}'$. Let a subscript represent the particular behavioral articulation, and a superscript represent the particular source of the articulation itself. Thus $\mathbb{B}_{iPhone\ ecosystem}^{stakeholder\ A}$ is a behavioral articulation of the iPhone ecosystem by stakeholder A.

- Let the model space be defined by outcomes related by transformations, these related outcomes and transformations being collectively referred to as a constraint articulation represented by the symbol $'\mathbb{C}'$. $'\mathbb{C}'$ is chosen to represent the particular ways in which the behavior modeled by the behavior articulation $\mathbb{B}$ is constrained by a sentient system. Let a subscript represent the particular constraint articulation, and a superscript represent the particular source of the articulation itself. Thus $\mathbb{C}_{iPhone\ ecosystem}^{stakeholder\ A}$ is a constraint articulation by stakeholder A of the way the iPhone ecosystem may be used.
- Let the value space be defined by demand situations experienced in terms of drivers, these related demand situations and drivers being collectively referred to as a value articulation represented by the symbol $'\mathbb{V}'$. $'\mathbb{V}'$ is chosen to represent the way a particular stakeholder experiences the behaviors of a particular ecosystem. Let a subscript represent the particular value articulation, and a superscript represent the particular source of the articulation itself. Thus $\mathbb{V}_{iPhone\ ecosystem}^{stakeholder\ B}$ is a value articulation by stakeholder B of the way the value of the constrained behaviors of the iPhone ecosystem is experienced.

A sovereign supplier can be accounted for by just the constraint and behavior articulations, the former authorizing just those behaviors across its perimeter in the latter that the closed value space of its sovereign stakeholders judges as satisfying their interests. To model a supplier surrendering aspects of its sovereignty to its indirect customers at its edges, however, a value articulation must be added to represent the different value spaces at the supplier's edges that it is choosing to satisfy.

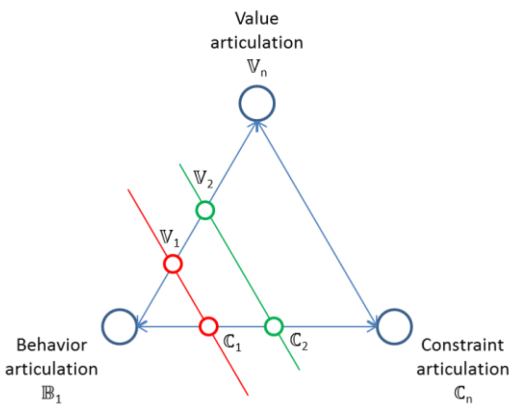

Figure 13: Increasing Scales of Ecosystem Complexity

The three articulations and their relationships are represented by the triangle in Figure 13. Approached from the supply-side perspective of task systems ($\mathbb{B}_1$), the progression through the two smaller triangles ($\mathbb{B}_1$- $\mathbb{V}_1$- $\mathbb{C}_1$ and $\mathbb{B}_1$- $\mathbb{V}_2$- $\mathbb{C}_2$) to the largest triangle ($\mathbb{B}_1$- $\mathbb{V}_n$- $\mathbb{C}_n$) represents a progression through increasing scales of ecosystem complexity. This progression is based on increasing varieties of value space corresponding to increasing varieties of indirect demand, implicating increasing numbers of organizations and task systems.

Modeling the determination of each articulation

The behavioral closures are identified by the modeler with the way task systems, sentient systems and stakeholder systems determine behaviors, constraints and values. A further distinction has to be made therefore between the articulation of each of the spaces, and the way relations within each articulation are determined with respect to particular supplier models, members of sentient systems, and stakeholders. These articulations of the way relations within each of the spaces are determined are correspondingly coordinations of processes, alignments of outcomes and anticipations of satisfaction of demand situations (see Table 4).

Table 4: apices, vertices and edges in each space

articulation	apices	vertices	edges
behavior	Coordinations	processes	events
constraint	Alignments	outcomes	transformations
value	Anticipations of satisfaction	demand situations	drivers

It follows that an articulation is defined as a triple (Z, D, N) comprising:

- Z, a **zero-level graph** of the articulation, being a directed acyclic graph (dag) of vertices and edges representing successions of events or outcomes or, in the case of the value articulation, states of experiencing,
- D, the directed acyclic graph of the coordinations, alignments or anticipations of vertices whose nodes we refer to as the **apices** of the articulation. The directed acyclicity represents coordinations of coordinations, alignments of alignment and anticipations of anticipations. All the leaves of D, but none of its apices, are vertices and edges of Z.
- N, the set of names that label the object types (vertices, edges and apices) of each articulation with each name being assigned by the modeler to corresponding objects in the world or ways of experiencing.

Particular business models of the behavior of task systems are therefore modeled as coordinations of coordinations of processes, particular sentient systems as alignments of alignments of outcomes, and particular stakeholders as anticipations of anticipations of satisfaction of demand situations. The recursiveness of these coordinations, alignments and anticipations are described as the height (or depth in the case of anticipations) of their respective dags.

Height in the behavior and constraint articulations

In modeling the parts of a task system or sentient system, the modeler identifies the sources of coordination or alignment of the processes or outcomes in the corresponding zero-level graph. It is convenient to define the **height** of an apex in the behavior articulation $\mathbb{B}$ and the constraint articulation $\mathbb{C}$ as the shortest distance between the apex and a leaf, with the apex being said to be **above** a leaf that defines its height (see Figure 14). On this basis, the apices for these two articulations can be partitioned into two classes:

- PA, the **primary** apices and
- DA, the **dual** apices,

subject to the constraint that **primary apices** are **above vertices** of Z and **dual apices** are **above edges** of Z. This enables a distinction to be made between

- the **primary subdag**, PS, as the subgraph of D whose nodes are the primary apices and whose leaves are vertices of Z; and

- the **dual subdag**, DS, as the subgraph of D whose nodes are the dual apices and whose leaves are edges of Z.

Each primary apex, a, **denotes** the subgraph of Z bounded by the vertices it subtends. This subgraph, Z_a, is equivalent to **the union of the subgraphs** denoted by its non-terminal descendants. Each dual apex, b, **denotes** the set of edges of Z that it subtends. This set of edges is equivalent to **the union of the sets of edges** denoted by its non-terminal descendants.

Depth in the value articulation

In the case of the value articulation 𝕍, however, a particular stakeholder can only express its composite experience of satisfaction with the way an overall demand situation has been responded to because of the subject-referenced nature of that experiencing. In order to identify its particular drivers, the stakeholder must refine the overall demand situation into constituent customer situations in which their experience is specific enough to make the drivers nameable, making the modeler's model of the stakeholder an anticipation of the stakeholder's subject-referenced experience of satisfaction. For the value articulation 𝕍 therefore, this nameability is dependent on the stakeholder's ability to name the particular value dimensions of their experiencing of satisfaction. This has consequences for its modeling:

- The zero-level graph of the value articulation 𝕍 cannot therefore be directly elicited from stakeholders, making it degenerate in that its source and target functions are empty (that is, its vertices and edges are completely disconnected).
- Apices are still partitioned into two classes forming primary and dual subdags.
- Each primary apex, a, still denotes the subgraph of Z bounded by the vertices it subtends, but this subgraph, Z_a, is equivalent to **the intersection of the subgraphs** denoted by its non-terminal descendants i.e. a customer situation can be common to many demand situations if experienced by stakeholders in the same way.
- To distinguish the particular characteristics of the value articulation 𝕍, therefore, it is convenient to define the **depth** of an apex in the value articulation as the shortest distance between the apex and leaf, with the apex being said to be **below** a leaf that defines its depth (see Figure 14).

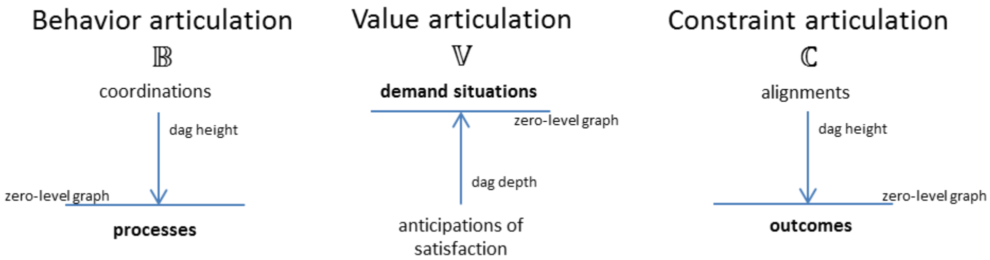

Figure 14: the relations of height and depth in the articulations

Both the construction and the naming of the zero-level graph of a value articulation 𝕍 therefore have to be derived from its apices. This contrasts with the other two articulations for which both apices and the zero-level graphs are directly observable. It follows from this distinction between height and depth that zero-level demand situations map to high-up coordinations and alignments, while zero-level processes and outcomes map to anticipations of satisfaction at some depth. It is this inversion of height and depth that enables the relation between supply-side and demand-side to be represented by the stratification in Figure 6.

Modeling the relations between the articulations

Whatever the scale of complexity (and therefore size of triangle in Figure 13) being described, three kinds of composition are possible between pairs of articulations, distinguishing different aspects of supply-demand relationships within the triple, summarized in Figure 15. In each case the two articulations composed assume no limitation introduced by the third:

- Behavior dependencies ($\mathbb{B}.\mathbb{V}$), describing the relationship between task systems and particular demand situations (for example as used in dependency structure matrices [137]);
- Accountability hierarchy ($\mathbb{B}.\mathbb{C}$), describing the accountability relationships under which different uses of task systems occur (for example as used by Jaques [138]); and
- Alignments of constraints to demand situations ($\mathbb{C}.\mathbb{V}$), describing the way particular behaviors of suppliers are aligned to the particular needs of customers' contexts-of-use (for example in building organizational Agility [85]).

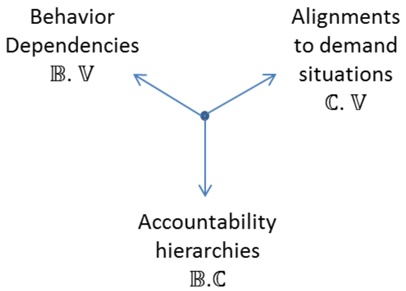

Figure 15: three kinds of composition within the triple

The three pairs of mappings

The vertices of the zero-level graph for the behavior articulation $\mathbb{B}$ (processes) map to edges of the zero-level graph for the constraint articulation $\mathbb{C}$ (transformations), while the edges of the zero-level graph for the behavior articulation $\mathbb{B}$ (events) define the state space and map to vertices of the zero-level graph for the constraint articulation $\mathbb{C}$ (outcomes). This describes the first pair of mappings between corresponding primary and dual apices of each articulation**.** This first pair defines the way a sentient system constrains the behavior of a task system in terms of an accountability hierarchy in Figure 15, but also the way a task system is accountable to a sentient system. Each mapping can be many-to-one, being non-injective and non-surjective. Thus there may be more than one way of creating a transformation, and there may be many transformations supported by any given process.

The relation of the value articulation $\mathbb{V}$ to the constraint articulation $\mathbb{C}$ is that the vertices and edges in each map to apices and dual apices in the other, so that increasing depth below zero-level for the value articulation becomes reducing height above zero-level for the constraint articulation. This is the second pair of mappings, creating relationships between the 'simplicity' (zero-level articulation) of the stakeholder customer's demand situation and the ‘complexity’ (heights) of the alignments of outcome needed for it to be satisfied. This second pair defines the way stakeholders value points and trajectories in the model space, in terms of the way constraints on the behavior of a task system may be aligned to demand. Again each mapping may be many-to-one, being non-injective and non-surjective, so that a customer situation may be satisfied by many outcomes while outcomes may also satisfy many different customer situations.

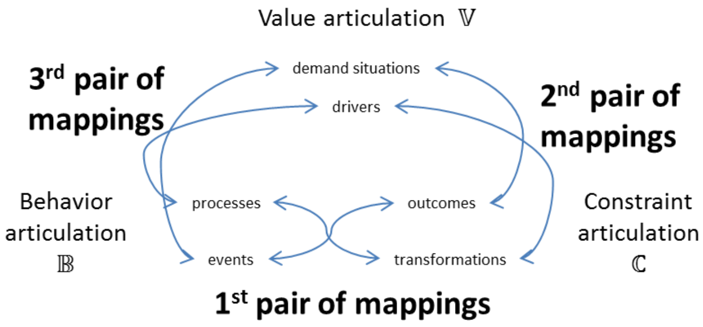

Figure 16: The mappings between the three articulations

A third pair of mappings is present in the mappings between the dual apices of the behavior articulation 𝔹 (coordinations of events) and the vertices of the value articulation ∀ (demand situations), and the apices of the behavior articulation 𝔹 (coordinations of processes) and the edges of the value articulation 𝕍 (drivers). This third pair models what is possible when all the constraints on behavior are derived from the value space, defining the fullest possible variation in behavior of which the task system is capable. Again these mappings may be many-to-one in either direction, each mapping being non-injective and non-surjective.

The representation of the value articulation

The three mappings summarized in Figure 16 represent the ways in which the articulations may be mapped to each other. In order to model the relations between all three, the subject-referenced third value articulation has to be transformed into a pseudo value articulation that can be object-referenced, so that the apices in its primary and dual subdags represent the unions of sub-graphs denoted by their non-terminal descendants. The dags still represent anticipations of satisfaction, expressed as customer situations. But the demand situations on the zero-level graph now come at the top of the pseudo primary subdag, and the pseudo zero-level graph is defined in terms of object-referenced requirements as vertices and drivers as edges.

Table 5: the value and pseudo value articulations

	Value Articulation		**Pseudo Value Articulation**	
zero-level graph	**vertices** demand situations	**edges** drivers		
Apices	**anticipations of satisfaction** customer situations		**anticipations of satisfaction** customer situations	
pseudo zero-level graph			**vertices** requirements	**edges** drivers

Modeling the effects of tempo

The timeframe 'T' within which an indirect demand can be satisfied will be defined by the succession of events relating its initiation to its conclusion, which take place within a timespan of discretion [139] within which choices are being made concerning the way events will succeed each other. The nature of the discretion within a timespan of discretion is the discretion of the members of the sentient and stakeholder systems able to determine the way events succeed each other within the timespan. Thus, while the succession of events can be mapped onto a standardized succession to establish a chronology of events taking place within the timespan of discretion, the demand situation within which the indirect demand is being experienced defines the timespan itself, with the discretion determining the particular ways in which the drivers in the situation are to be satisfied. An effects ladder is therefore a way of describing how a situation is of moment to the customer stakeholder(s) experiencing it in terms of drivers, and how larger and smaller situations may be organized in relation to each other in terms of their relative moment with respect to the overall demand situation containing them all (see Appendix B, p81, for more on effects ladders). And it is through the processes of surrendering sovereignty that any given supplier subordinates its own discretion to satisfying the driving interests of its customer stakeholders.

Succession can therefore be described as taking place along a chronos axis defined by reference to a shared measure of time, while moment is defined along a kairos axis that is particular to the effects ladder organizing a particular way of experiencing a demand situation. In the use of the smartphone platform in organizing a blind date, the duration of this chronos timeframe (T_d) might be minutes; for the use of the UASs supporting the execution of an interdiction mission it might be hours; and for the use of orthoses as part of an episode of care, it might be days. In each case the chronos timeframe of the succession of events within which the smartphones, UASs or orthoses used can be acquired or supplied (T_s) is larger, with the chronos timeframe of orchestration of the various suppliers in the customer situation (T_a) somewhere in between ($T_s > T_a > T_d$).

- Modeling an ecosystem of suppliers and customers therefore has to be able to describe the successions of events across all three chronos timeframes.
- It also has to be able to distinguish between those events and processes occurring within the timeframe of demand T_d, and those that are not but which nevertheless need to be made present as re-presentations within T_d in order to participate in its succession.
- In modeling the task systems, sentient systems and stakeholder systems ultimately determining relations between behaviors, the distinction also has to be made between the chronos and kairos axes. Thus if the processes structuring behavior within the task systems, sentient systems and stakeholder systems are themselves structure-determined, then the modeler need only be concerned with the chronos axis. But to include their being structure-determining within a relevant timeframe, therefore exercising discretion, the kairos axis has to be represented as well. This is a distinction made by the modeler as to whether an attributed relation is structure-determined, rendering it reactive, or is structure-determining of reactive behavior, rendering it goal-seeking [28]. In the latter case it is modeled as know-how

modifying the ways in which reactive behavior is determined, which may include the processes by which the goals themselves may be set.

- These distinctions of chronos timeframe and kairos relation to structure-determination have to be present in the conceptual or structural modeling in order to represent the modeler’s hypotheses (see Appendix D, p97, for the particular characteristics of conceptual or structural modeling).

The modeling ontology

The distinctions needing to be represented within a model of triple articulation are therefore as follows:

- The state, model and value spaces are articulated by vertices and edges,
- The apices must be partitioned into structure-determining and structure-determined coordinations, alignments or anticipations.
- The relation to the demand timeframe doubles all of the apices, vertices and edges for the behavior articulation, given that there may be events and processes that do not themselves take place within the demand timeframe, and there may be coordinations that are not themselves determined within the demand timeframe.
- There may be structure-determined alignments within the constraint articulation that are not themselves determined within the demand timeframe, and structure-determined anticipations within the value articulation that are not themselves determined within the demand timeframe of a customer situation.
- Finally the structure-determining alignments of sentient systems and the structure-determined anticipations of stakeholders are always taking place outside the demand timeframe.

This produces 18 distinctions, shown in Table 6, defining the extended ontology of a triply articulated model.

Table 6: The distinctions defining the three articulations

	Behavior articulation		Constraint articulation		Pseudo Value articulation	
Structure-determining	**goal-seeking coordinations**		**goal-seeking alignments**		**goal-seeking anticipations**	
	1:know-how	2:design**	9:accountability unit**		14:stakeholder**	
Structure-determined	**reactive**	**coordinations**	**reactive**	**alignments**	**reactive anticipations**	
	3:capability	4:system**	10:syn-chronization	11:fusion**	15:customer situation	16:demand situation**
Relation to State Space	**state space**		12:outcome		17:requirement	
	5:event	6:trace*				
	behavior space		13:transformation		18:driver	
	7:physical process	8:digital process				

* - the trace is a re-presentation of an event outside the demand timeframe.
** - the structuring of the process is not present within the demand timeframe

The objects, behaviors and ways of experiencing referred to by these distinctions are described below, together with particular symbols that can be used by a modeler in an implementation of projective analysis:

1&2 - know-how and design. This is knowledge that resides in a task system about how to change the way capabilities determine the behavior of processes. The more the capabilities are parameterized, the more important this know-how becomes in determining the ultimate behavior of processes.

Figure 17: structure-determining systems

3&4 - capability and system. This is the ability of a task system to determine the way processes generate events and outcomes. Capability has the same relation to process as software has to its run-time behavior.

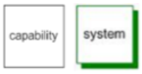

Figure 18: structure-determined systems

5&6 - event and trace. An event is an output of a task system (i.e. a product or service) that is not commercially available outside of the boundaries of the entity, contrasting with an outcome which is commercially available. Typically an outcome is the consequence of a chain of events and outcomes. A trace is a re-presentation of an event occurring outside the demand timeframe.

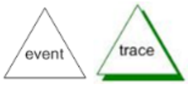

Figure 19: single states

7&8 – physical and digital process. The behaviors, shaped by capabilities, which generate events or outcomes for a given set of input conditions.

Figure 20: single behaviors

9 - accountability units. These are the units within a sentient system (and ultimately individual roles) that would show up in the organization chart of a supplier or customer defining the way control and accountability has been defined in pursuit of the organization's goals.

Figure 21: structure-determining organization

10&11 – orchestration and data fusion know-how. This is the know-how in the social interaction within a sentient system required to orchestrate the behavior of task systems engaging in a contractual relationship, whether formal or informal, or the algorithm required to align data from task systems and customers.

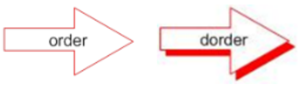

Figure 22: structure-determined organization

12 - outcome. This is the output of a task system under the control of a sentient system (i.e. a product or service) that is commercially available beyond the perimeter of that sentient system's organization.

Figure 23: complex states

13 – transformation. This is the composite set of processes, the output of which is an outcome. It contains within itself a number of processes at a different scale of detail.

Figure 24: complex processes

14 – stakeholder. A stakeholder defines a particular way of experiencing demand situations refined in terms of customer situations, the way of experiencing customer situations expressed in terms of drivers.

Figure 25: structure-determining of value

15&16 - demand and customer situations. For a supplier, a demand situation is the type of business in which it is operating. For a customer it is their ultimate demand for effects that has been refined into an organization of customer situations of moment to the demand situation. The customer situation is the specific customer context-of-use within which products and services supplied are being used.

Figure 26: structure-determined value

17 - requirement. This is the same as an outcome, except defined for use by a customer situation, and defined independently of the customer situation as a context-of-use.

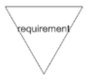

Figure 27: demand for an outcome defined independently of context-of-use

18 - driver. A driver is the dimension of satisfaction in terms of which a requirement, customer situation or demand situation is experienced by a customer stakeholder.

Figure 28: dimensions of experienced value

Implementing Projective Analysis

Building a triply articulated model requires that the modeler identify relations between objects, and between those objects and the ways they are experienced, referred to as primitive relations. This is done using visual modeling to elicit these primitive relations across the relevant domain of interactions based on Figure 17 to Figure 28 and Table 7. The elicitation is done with individuals having direct knowledge of the suppliers' models.

The complex relations across these primitive relations are then analyzed to generate a stratification matrix of the form shown in Figure 32. The sub-matrices in this are used to represent the stratified relationships of embeddedness described in Figure 8 (the diagonal set of red sub-matrices), the other matrices representing different aspects of how these layers are aligned to each other, including the hierarchical relationships constraining the supply-side behaviors. These complex relations describe the structural properties of the model of triple articulation, and are of three different kinds:

- Monadic relations, being naming conventions used in the formation of the stratification.
- Dyadic relations, being chains of (dyadic) primitive relations, for example hierarchies and activity chains.
- Triadic relations, being circular relations occurring within a timespan of demand (T_d) and therefore irreducible to a succession of dyadic relations, an example of which is shown in Figure 31. These triadic relations represent relationships between outcomes and contexts-of-use (customer situations) in which there is a three-way relationship between dynamic coupling by an ordering relation, the design of the outcome being supplied, and the way that outcome is experienced by the customer within its context-of-use. These triadic relations differ from feedback relations because all parts of the relation occur within the same time interval, and define the c-type, K-type and P-type value propositions in Appendix C, p91.

The resultant matrices are then analyzed using a method that describes the overlapping patterns and structural 'gaps' within and between the layers of the stratification [140, 141], examples of which are shown in the next Chapter. The use of projective analysis therefore involves four major stages, summarized below:

(1) Preliminary analysis establishing the modeler's interest and the resultant scope of the ecosystem to be modeled, described in more detail in Appendix B, p81.
(2) Visual modeling of the primitive relations within the chosen domain of interactions, focusing particularly on the different types of value proposition in Appendix C, p91.
(3) Analysis of patterns of stratification across the ecosystem as a whole, using rules in the ways described below.
(4) Analyses of the architectural patterns across this stratification, as described in Chapter 5.

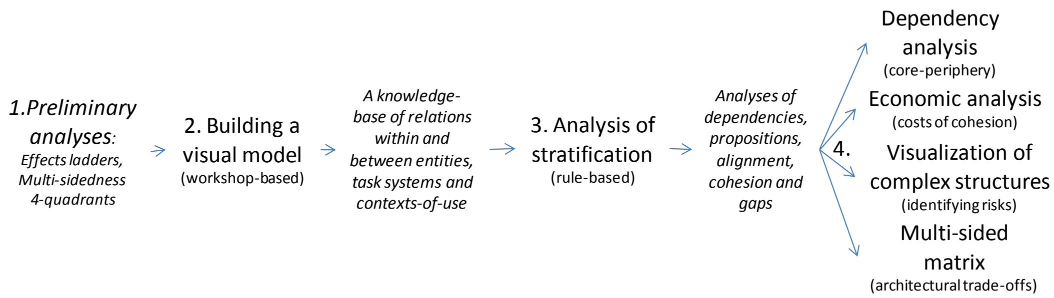

Figure 29: Using PAN to support a projective analysis

Defining primitive relations

Table 7 shows the particular set of primitive relations between the objects in Table 6. This particular set is used in an implementation of projective analysis referred to as PAN (Projective Analysis), and excludes transformations and requirements. Transformations are not included because they are implied by the relations between outcomes, and requirements are implicit in the direction of the primitive relation between outcomes to customer situations. The primitive relations within each of the articulations preserve the directed acyclicity both within its zero-level graphs and dags, and between the articulations for all three pairs. An example of a set of primitive relations is shown below in Figure 30.

Table 7: primitive relations modeled within and between articulations

	Constraint Space				Behavior Space				Pseudo Value Space			
	Alignment			Model	Resource		Task behavior		Anticipation			Value
	unit **	sync 'n	fusion **	outcome	know-how*	cap'y *	process *	event *	stake-holder **	d sit'n **	c sit'n	driver
stakeholder**										→		
d situation**	→**										→	
c situation				→			→**				↺	
driver											→	
unit**	↺	→	→		→	→	→**					
sync'n		↺		→	→	→					→	
fusion**			↺	→				→			→**	
outcome							→				→	
know-how*					↺	→					→	
capability*						↺	→					
process*	→**			→	→	→		→			→**	
event*							→					

* These all exist in physical (occurring within timeframe) or digital forms (not occurring within timeframe).
** These exist only in digital form

An example of a set of primitive relations represented visually is shown below in Figure 30. Each relation in this visual model becomes a line in a knowledge base of primitive relations. A fragment of the knowledge base generated from this visual model is shown in Table 8. Each line is a primitive relation between two particular named types of object (the different forms of relation summarized in 'The modeling ontology', p45).

Table 8: A fragment from the orthotics model knowledge-base

unit\orthotics_dept controls khow\orthotist.
unit\orthotics_dept controls capy\orthotist_facilities.
trace\orthotics_waiting_list supplies process\assessment_and_measurement.
capy\orthotist_facilities determines process\assessment_and_measurement.
khow\orthotist determines khow\technician.
khow\technician determines capy\orthotist_facilities.
unit\orthotics_dept controls khow\technician.
process\i_distn supplies event\o_goods_in.
process\m_distribution supplies event\o_goods_in.
event\o_goods_in supplies process\assessment_and_measurement.
process\assessment_and_measurement supplies event\needs_adjusting.
process\b_stock_distribution supplies event\o_goods_in.
process\adjustment supplies event\adjusted_stock.
event\adjusted_stock supplies process\adjustment_fitting.
event\needs_adjusting supplies process\adjustment.

Deriving the structural characteristics of a model of triple articulation

The primitive relations form a knowledge-base that can then be analyzed for complex relations. Among these complex relations are the accountability hierarchies, the stratified relations between the supply-side and the demand-side showing how task systems are aligned by particular patterns in relation to indirect demands (described in Appendix C, p91), and the dependencies defining the succession of events within the different timeframes (corresponding to the three kinds of composition summarized in Figure 15).

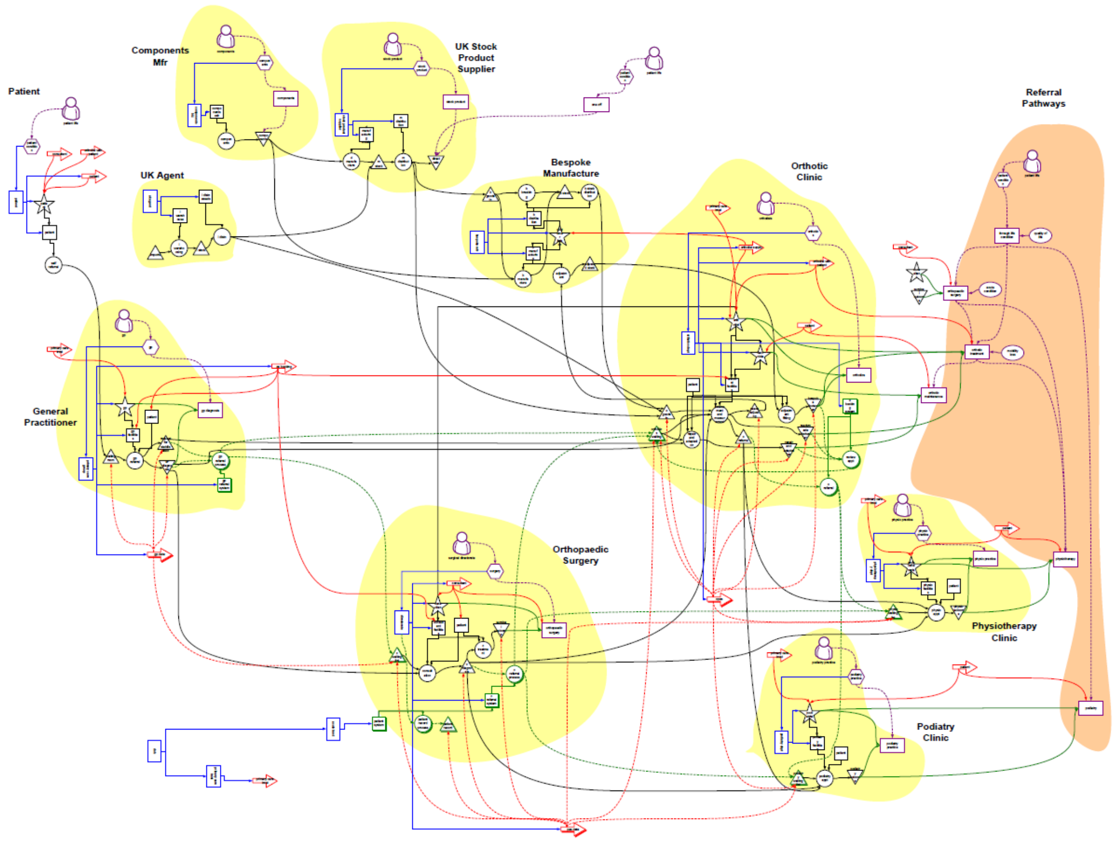

Figure 30: A visual model of primitive relations for the orthotics case

Each complex relation is a composition of primitive relations defined using first order logic. An example of the triadic type of relation is shown in Figure 31. The suppliers (units) have the ability to shape the way an outcome satisfies a customer situation (csitn) on the basis of knowledge of the customer situation used to shape that outcome dynamically through an ordering relation. The primitive relationships corresponding to this complex pattern are shown below.

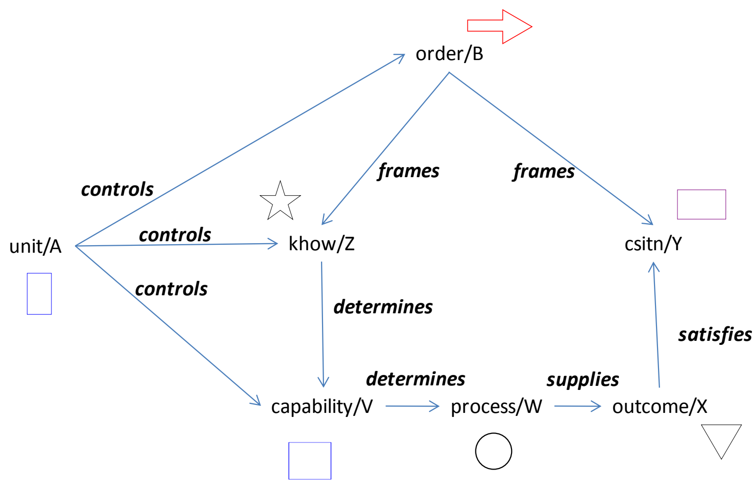

Figure 31: The pattern of primitive relations shaping an outcome to a customer situation

An example of an operator is shown in Table 9, in which, given a chain of traces and processes leading to a process-outcome relation, the operator relates the traces as 'tracevents' to the outcome.

Table 9: an example complex operator

22. **outcome_trace**
R1: trace process
R2: process event
R3: event outcome
R4: trace dprocess
R5: dprocess trace
outcome tracevent ←
((R1 ; R2 ; R3) ∪
(R4 ; R5)* ; R1 ; R2; R3))$^{-1}$

The output of this complex operator takes the form of a relation of the form outcome-tracevent, and is shown in Table 10.

Table 10: an example of output from a complex operator

"complex operator 22: outcome_trace"

"signature: ","outcome tracevent"
"podiatry_outcome podiatry_waiting_list"
"physio_outcome physio_waiting_list"
"readymade_footwear c_waiting_list"
"podiatry_outcome c_waiting_list"
"physio_outcome c_waiting_list"
"surgical_outcome c_waiting_list"
"bespoke_footwear c_waiting_list"
"bespoke_footwear orthotics_waiting_list"
"physio_outcome orthotics_waiting_list"
"podiatry_outcome orthotics_waiting_list"
"readymade_footwear orthotics_waiting_list"
"repair_and_adaptation orthotics_waiting_list"

The content of the layers and the relationships between them are therefore defined by the complex operators, of which there are about 100. The PAN tools analyse these complex relationships to identify architectural characteristics across the different layers.

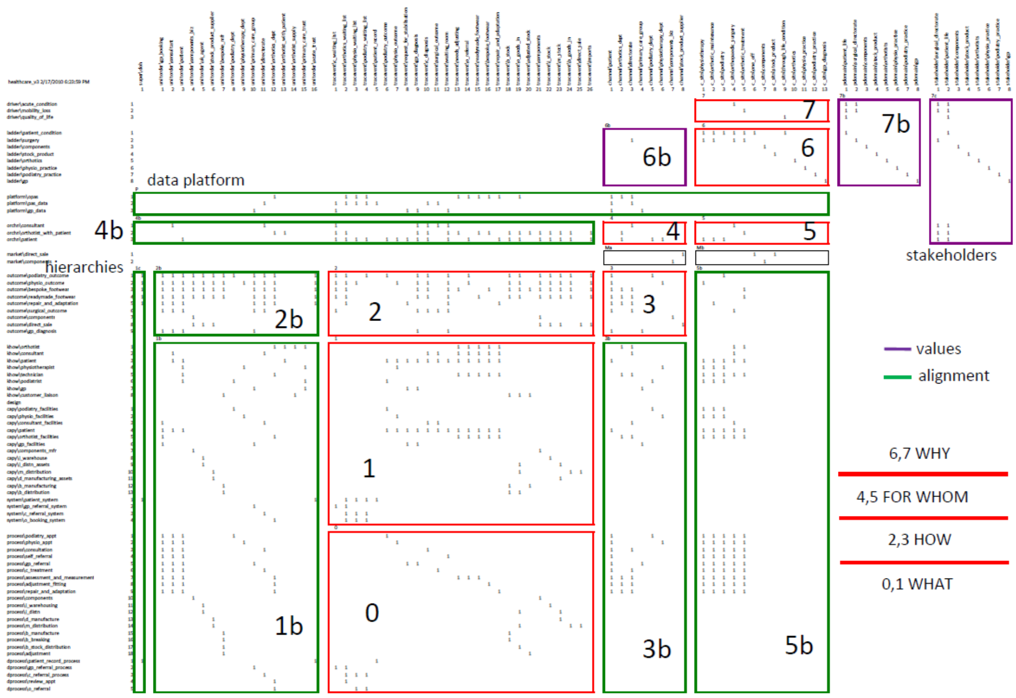

Figure 32: stratification matrix for the orthotics case

Analyzing the structural 'gaps'

Alignment to demand is described by the structural connectivity within and across the different layers of the stratification. This alignment is analyzed using a landscape analysis that examines the structural 'gaps' [141] in a set of layers supporting the layer immediately above them (the methods of analysis being based on Q-analysis [30] [140]). For example, the matrices in Figure 33 are derived from the full stratification matrix in Figure 32 by identifying just those rows supporting non-empty rows in sub-matrix 3, and then identifying just those parts of sub-matrices 0, 1/1b & 2/2b directly supporting sub-matrix 3.

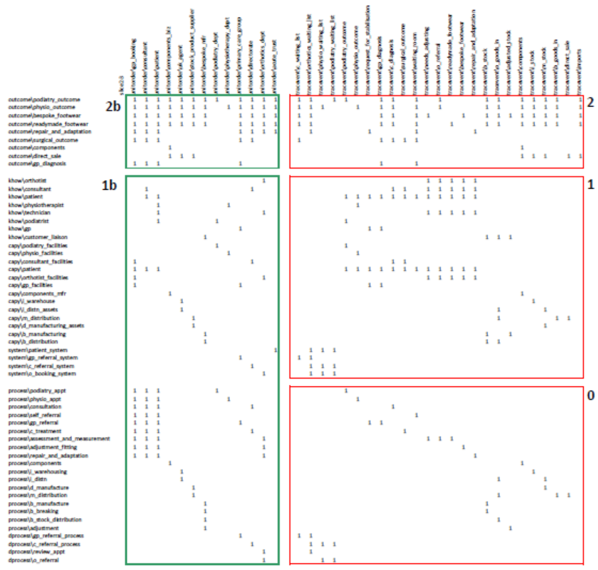

Figure 33: sub-matrices 0, 1 & 2 of the stratification

The landscape in Figure 34 is analyzing the column simplices in Figure 33 to identify the extent of the overlapping vertices between them. All of these simplices have to be brought together in support of layer 3, so any lack of overlap constitutes ‘gaps’ having to be bridged in the layers above, as described in Figure 9 and Figure 10.

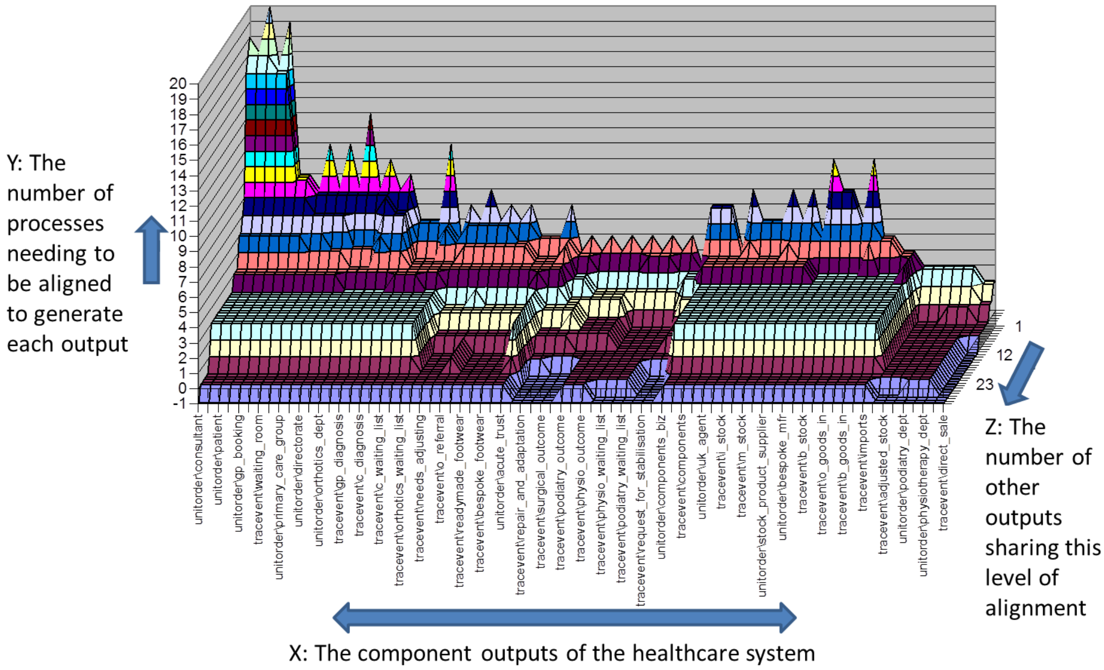

Figure 34: A landscape analysis of the sub-matrices supporting layer 3 in the stratification

- The ‘x’ axis labels in Figure 34 are the labels of the column simplices of the sub-matrices in Figure 33. These simplices are sorted into a sequence so as to create the maximum overlap with their immediate neighbors.
- The ‘y’ axis is the number of overlapping vertices in each simplex less 1, providing a measure of the dimensionality of the overlap. Thus the higher the ‘peak’, the greater the overlap, for example between the orthopedic consultant, the patient and the general practitioner. The orthotic treatment process is shown at a lower level of dimensionality.
- The ‘z’ axis represents the number of simplices that have overlaps at that level of ‘y’. The depth of the ‘foothills’ are therefore a measure of how extensive the overlaps are with other parts of the simplicial complex at that level of dimensionality.

This landscape is complex, with many ‘gaps’ between its constituent activities, contrasting with the support given by the orthotist to the patient in layer 6 (the sub-matrices in Figure 35).

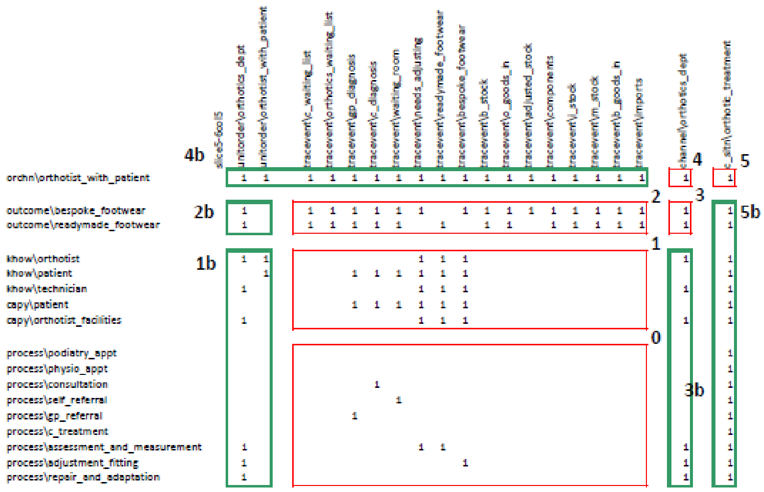

Figure 35: The submatrices directly supporting the orthotist's treatment in layer 6

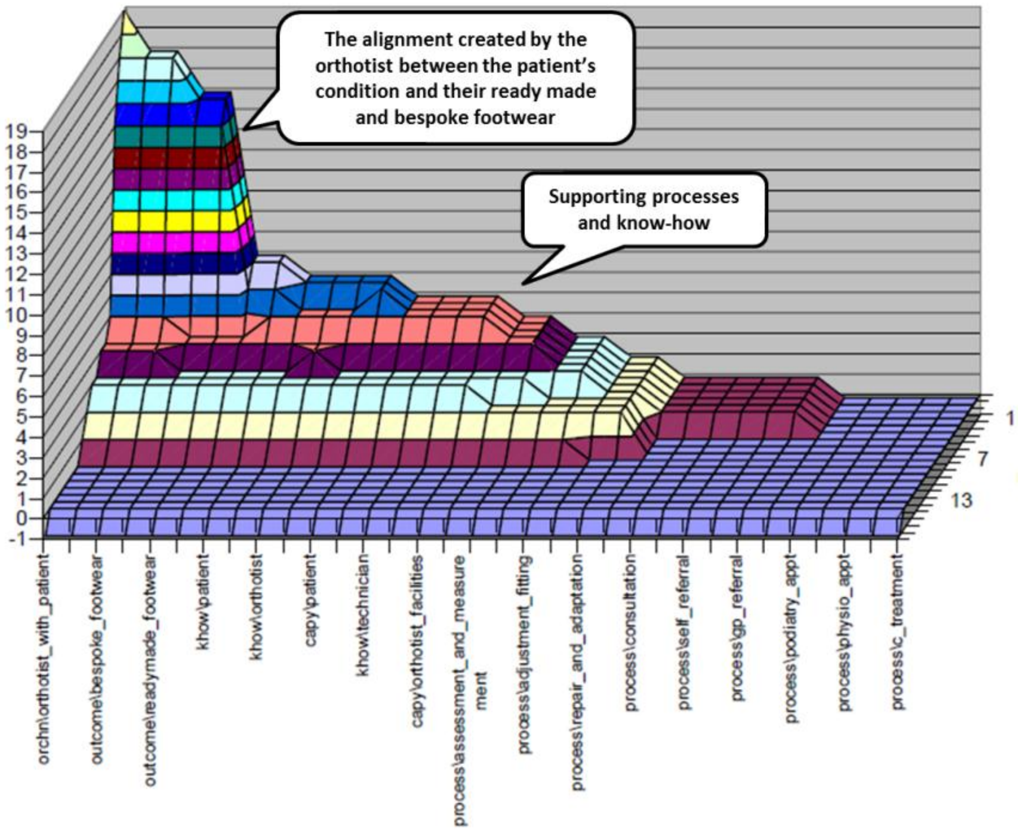

Figure 36: a landscape analysis of the alignment of the orthotist's treatment with layer 6

In this case (Figure 36), the landscape is of the row simplices supporting layer 6, showing how the complexity in the other layers is subordinated to the orthotist's relationship with the patient, the implication being that the complexities of coordinating with the other clinicians is managed elsewhere in the ecosystem.

The meaning of the peaks, plateaus, and valleys depend on the particular alignments being examined within the context of the stratification as a whole. This is done by 'slicing' sub-matrices from the perspective of particular demands arising within the different layers. The peaks on the y-axis represent high levels of overlap between neighboring simplices, and plateaus on the z-axis indicate the extent to which a given level of overlap extends across other simplices. Valleys between the peaks and plateaus in a given stratification reflect the absence of relationships between neighboring simplices, indicating structural 'gaps'.

Relating the ontology of projective analysis to the ontologies of existing methods

Architectural evaluation usually focuses on the supplier's domain from which a product or service is to be provided in response to some customer's direct demand. The supplier approaches architecture from the starting point of the scenarios in which their products or services are used, defining the functional and non-functional characteristics of the customer's demand, in relation to which the supplier can then design a satisfactory architecture [142].

The supplier combines task systems and sentient systems [143], which can be described as a three-way relationship between three sub-models (shown in Figure 37) of an organization (1) controlling resources (2), constraining and constrained by the precedence relations imposed by the nature of the task system (3). Primitive relations are defined between the elements within and between these sub-models, from which complex relations can be derived that describe architectural patterns [144].

Figure 37 assumes stakeholders with sovereignty over the supplier's sentient system, ensuring that their interests are served. What patterns may be described depend on the primitive relations defined by the modeler [142], but can be used to consider the potential consequences of misalignment between the sentient system of the supplier and the desired architecture of the task system [145]. Elaboration of the primitive relations within and between the sub-models can give insight into architecture not only at the level of the sentient system but also at the level of the relations between software modules and data within the task system itself [137, 146, 147].

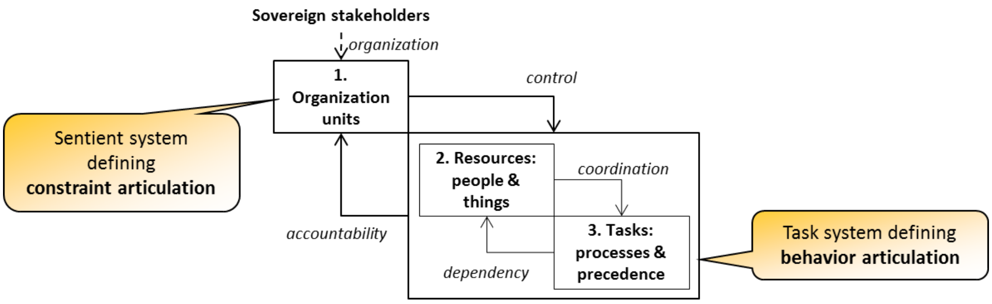

Figure 37: The sub-domains of the supplier

However, suppliers pursuing indirect value within an ecosystem must relate to the demands of their indirect customers, and in so doing must surrender elements of their sovereignty. For example, the interests of clinics run by orthotics suppliers cannot be assumed to be the same as those of their patients who are using orthoses to manage their conditions. This means adding a fourth sub-model that can be used to describe the indirect demands arising within the variety of customer situations to which the supplier must respond, shown in Figure 38.

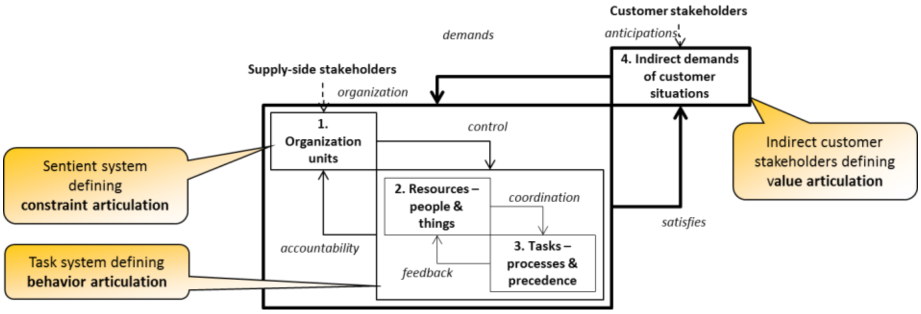

Figure 38: Adding the demand-side

Projective analysis aims to include a model of this variety of demands, creating an environment of indirect demands placed on suppliers and customers. Adding this fourth sub-model therefore enables a model to be built of both the supply-side and the demand-side architectures, providing a basis from which to judge both whether it is in the supplier's economic and competitive interests to satisfy indirect demand, and if so, how.

The relation to the ontologies of existing methods

A projective analysis is a model of a supplier's models, using methods of conceptual or structural modeling to describe three levels of openness in the supplier's relationship to the ecosystem. (See Appendix D, p97, for the relationship between this and other methods).

These methods are constrained by the ontologies that they permit. Their ontologies are 'upper' ontologies defining the different categories of things and relationships between things that a modeling method makes it possible to represent [148], determining the forms of knowledge that can be represented in particular domains [149, 150]. Many such frameworks exist, for example Zachman [151], DoDAF [152], or Federal Enterprise Architecture [153]. The characteristic of all of these ontologies is that they model physical and digital structures and behaviors, and the accountability hierarchies under which these operate are subject to a single sovereign supplier, whether virtual or not. They assume a closed value space, however, modeling only two levels of openness. As a consequence, only relations reducible to dyadic form need be modeled.

In order to extend these ontologies to include a model of an open value space, projective analysis needs to admit multiple sources of sovereignty by adding representations for network relationships across multiple suppliers and customers, and for the organization of direct and indirect customers' contexts-of-use [89]. This demands an expanded 'upper' ontology capable of representing different ways of aligning the supply-side to the demand-side, in contrast to the solely supply-side focus of a modeling method such as IDEF or UML, working across the boundary between systems and their immediate organizational context [154]. This demands complex operators reducible to triadic relations. By analyzing patterns of relationship across the sub-models in Figure 38 using this expanded ontology, the different forms of alignment can be analyzed with respect to different forms of demand.

Conclusion

These modeling methods will describe the stratification of an ecosystem and provide a basis for analyzing its structural characteristics. The resultant analyses provide support to a supplier evolving the agility of its business architecture in order to capture indirect value within the larger ecosystem.

Chapter 5 - Evidence of use

Outline of contents

- **Introduction** – taking up the perspective of indirect customers
- **Quantifying Indirect Value** – modeling the effects of variation in indirect demands
- **Identifying Risks** – analyzing where the gaps are in the stratification
- **Defining characteristics of platform architecture for mitigating risks** – identifying what the ecosystem platform architecture has to bridge

Introduction

The solution to what wasn't working for the Nokia, the MoD and Orthotics cases in Chapter 1 was for the supplier to include indirect value in its considerations. What made this difficult for the supplier was that it involved the supplier surrendering aspects of its sovereignty to indirect customers – mobile phone users, mission commanders or patients – in order that they might be enabled to reduce their costs of alignment, in return for which savings the supplier might reap some benefit. There were particular instances of this happening with Apple's use of the iPhone platform [11], with a UAS platform provided by Thales for the MoD [2] [91], and Kaiser Permanente achieved it for healthcare in the USA [98]. But there was no systematic framework within which to model this extended role for the supplier.

Parts II and III argued that in order for the supplier to reap those benefits, it needed to be able to compete in supporting indirect demands, in which the indirect value that it could capture depended on the particular forms of agility it could make available to its indirect customers. The supplier therefore needed to be able to describe and understand the socio-technical business ecosystem within which it was competing in order to quantify the potential benefits to both itself and its indirect customers, to identify the risks it faced, and to mitigate the possible effects of those risks through the way it architected its agility. Chapter 4 described a method of projective analysis that made this possible. This section describes examples of the use of this method.

The practical uses of projective analysis described in this section evidence its use in describing the complexity associated with a supplier adopting a platform strategy, quantifying its benefits, identifying the attendant risks, and mitigating those risks. The case studies describe:

- Quantifying the indirect value available to a supplier in reducing the costs of alignment of its indirect customers
- Identifying risks to a platform strategy based on the variety of indirect demand situations it has anticipated needing to support
- Defining the architectural characteristics of a platform capable of supporting the pursuit of indirect value.

Quantifying Indirect Value

Introduction

Three projects have been undertaken quantifying indirect value. The most recent examined the economics of managing MoD surface capability on a through-life basis. A change in the underlying architecture of the assets, combined with a C4ISTAR platform architecture altering the ways in which they were able to interoperate, produced an estimated 40-50% saving on the operational costs, with 15% of this saving coming from a reduction in the variation in the operational costs across the anticipated variety of indirect demands for surface capability [155].

A second project examined the potential savings available to the Swiss Federal Chancellery from improving its eGovernment responses to requests for information from its citizens and businesses. The project examined the variability in the nature of the requests, and the variety in the forms of collaboration needed between departments within and outside the Government's administration to respond to these requests. Two investment options were considered, the first digitalizing the existing records and their organization, the second using a platform architecture designed to support the variability in the nature of the requests. The total cost of the second option produced an estimated 80% saving over the first option, with 50% of this saving coming from a reduction in the variation in the costs of collaboration between departments across the anticipated variety of requests [95].

A third project examined the economics of responding to demands in theatre for the interdiction of fleeting targets using UASs. A baseline was defined using existing assets, and the economic impact was assessed of changing the role of the UAS to one of providing a platform architecture supporting the interoperation of other assets in theatre. The result was that a 40% total saving would have been possible on the operational costs, with 30% of this saving coming from a reduction in the variation in the operational costs of missions across the anticipated variety of mission types [94].

In each case, the supplier of the existing equipment – surface combatants, search platforms and UASs – was able to generate significant indirect value for its indirect customers – mission commanders and lead departments in government – as a result of taking into consideration the indirect customers' costs of alignment. The case example that follows examines the third of these projects in more detail.

The UAS case - establishing the value of agility

The UK operational forces deployed in theatre were facing a much wider variety of mission types than had been planned for in the acquisition phase of the UASs they were using, demanding a much greater level of agility from the forces in the way UASs could be used. The result was high levels of expenditure on Urgent Operational Requirements (UORs) that could fill the gaps in operational capability, creating costs of alignment that were as great as the total planned cost of the UAS itself through its life. The question asked by the client here was what commercial model would have had to be used at the time of acquisition to take these costs of alignment into account?

The problem, in this case the high levels of unplanned-for expenditure, arose from the need to better align the acquisition process to supporting a much greater variety of demands on the UAS capability arising from its indirect operational uses.

Background

Comparisons had been made between three generations of use of UAS [3], the key difference being between the 'single-sided' first two generations and the 'multi-sided' third generation, summarized in Table 11 (See Appendix A, p77 on multi-sidedness). In the case of

UAS I, what was acquired was equipment to a specification—forward observation for artillery. In the case of UAS II, this was being acquired as a solution to Divisional Command's requirements for information. In both of these cases, there was a direct customer to whom the capability was being delivered. What made the difference in the third generation of use was the need to support indirect customer situations demanding multiple roles for the UAS through the way it could interoperate with other assets and indirect customers. This third generation use had not been planned for, but emerged in response to urgent operational requirements arising in theatre.

Table 11: Summary of Market Characteristics of Three Generations of UAS System

	Single-sided use		Multi-sided use
	UAS I	UAS II	UAS III
Indirect customer situations	Over-the-horizon targeting	Divisional Command's information requirements	Situations dependent on presence of persistent surveillance (e.g., interdicting fleeting targets)
Indirect customers	-	-	Soldiers on ground, airborne strike, synchronization command
Direct customers	Artillery Battery	Divisional Command	Divisional Command
Other suppliers	*No other suppliers because the only service provided is to a direct customer*		Strike assets, ground, airborne and space sensors, communications interfaces
Multi-sided platform	*Not multi-sided because only one direct customer is supported*		UAS platform + systems supporting collaborations

Thus in the third generation use of the UAS, while each variety of collaboration required its corresponding set of indirect customers and other suppliers ('complementors' in Appendix A, p77), in practice the costs of aligning the way these indirect customers and other suppliers could interoperate (i.e. the cost of the *orchestrations* supporting these collaborations) was very high. This was because of the *ad hoc* methods that had to be used to compensate for gaps in the ability of the existing UAS to support them (one example was using reconnaissance aircraft to fill gaps in communications capabilities, another using substitute UASs to bring different sensors into theatre). These costs of filling gaps in current operational capabilities and aligning particular orchestrations so that they could be used operationally were defined as alignment costs*.* The costs of alignment of each particular orchestration was the cost of the particular composite operational capability it provided, including any one-off costs incurred in compensating for gaps in existing capabilities. From the perspective of supporting indirect demands, these costs of alignment therefore represented the current expenditure by indirect customers and suppliers, defined by the expenditures on the variety of forms of their collaboration.

Assessing the Impact of New Flexibilities on the Value of Indirect Demands

A major reason for the very high costs of alignment with the third-generation use of the UAS was the limited range of orchestrations that the second generation UAS could support due to inflexibilities built into its requirement resulting from its one-sided view of its market. This was a systemic issue where the military equipment acquisition program was driven by the needs of the particular unit within an existing service (i.e., the Army, Navy, etc.) and by the concerns of the front-line commands being delivered through stove-piped Integrated Project Teams (IPTs). Thus, the UAS was delivered to the artillery unit as the direct customer when, in fact, the value of the capability was in the information product it could deliver to its indirect customers, being a variety of commanders, units and even individual soldiers/airmen. At the time of the acquisition of UAS II, although known about, this wider variety of uses had been left for funding on a contingency basis using UORs, as indeed happened. In the light of the experience with UAS III, the question therefore arose as to what value additional flexibilities the UAS might have had, had an explicitly multi-sided view of its market been taken at the outset. This was a key question for the military organization which habitually took a single-sided view of the markets for which it made acquisitions.

The potential value of multiple alternative uses of the UAS was established using Real Option Theory [94]. Real option valuation considers what value can be attached to a reduction in the spread of future expenditures as a result of an investment. This provides a way of valuing the impact of greater agility in the UAS on the economics of different orchestrations as well as of valuing the direct impact of an investment in agility. In this approach, investment increases the variety of orchestrations that can be supported by the UAS at the tempo required in theatre, thereby making the operational force more agile. The result reduces the spread in expenditures generated by the variety of orchestrations that have to be supported by the force. Thus instead of having to re-purpose other assets to meet a particular operational need, the need can be met by flexing the existing UAS.

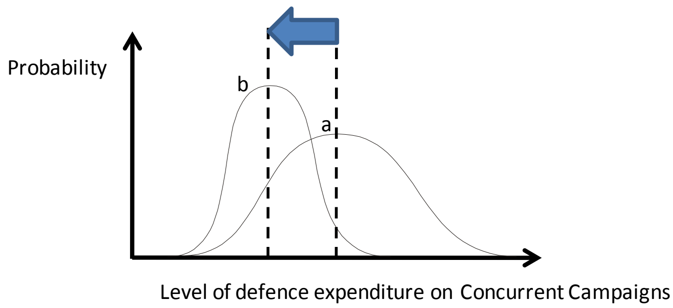

Figure 39: Real Option Valuation

The *difference* between the two curves ‘a’ and ‘b’ in Figure 39 therefore represents the impact of exercising a real option that reduces the average defence expenditure through the reduced cost of using the UAS instead of a more expensive asset (a ‘trade’); and reduces the future potential spread in defence expenditure as a result of the UAS’s ability to participate in a wider variety of orchestrations. These two values, the second of which is established by real option valuation, correspond to the two kinds of value generated in by indirect demands: the direct value from the supplier’s relationship with the direct customer, and the indirect value created by the platform’s support for the collaborations between indirect customers and other suppliers.

The analysis and its results

The analysis started by establishing the variety of mission situations that might occur across the potential range of concurrent military campaigns, represented in the form of an effects ladder. Monte Carlo analysis was then used to establish the relative frequency of occurrence of these mission situations in any one year, and projective analysis was used to model the particular ways in which the UASs would be used, both as currently configured and as a result of investment to increase their flexibility. The mission situations chosen are summarized in Table 12.

Table 12: The variety of mission situations chosen

Mission Situations		Decisive Issue	Controlling Issue
1	Individual in Afghan-Pakistan border	Disrupts terrorist command	Hard to see, effects easy
2	Individual in Kabul Blue Zone	Disrupts terrorist command	Hard to see, effects difficult
3	Stinger missiles in Baghdad city centre	Neutralization of manoeuvrist threat	Hard to see, effects difficult
4	Shoot-and-scoot in tribal lands	Neutralization of manoeuvrist threat	Easy to see, effects difficult
5	Terrorist escape by sea	Disrupts terrorist command	Hard to see, effects easy

The resultant models (shown in Figure 40) were used to generate stratification matrices from which costing templates could be derived. These costing templates were used to establish the full costs of alignment of each type of mission situation before and after investment, providing the basis for the Real Option analysis when combined with the results of the Monte Carlo analysis of variation.

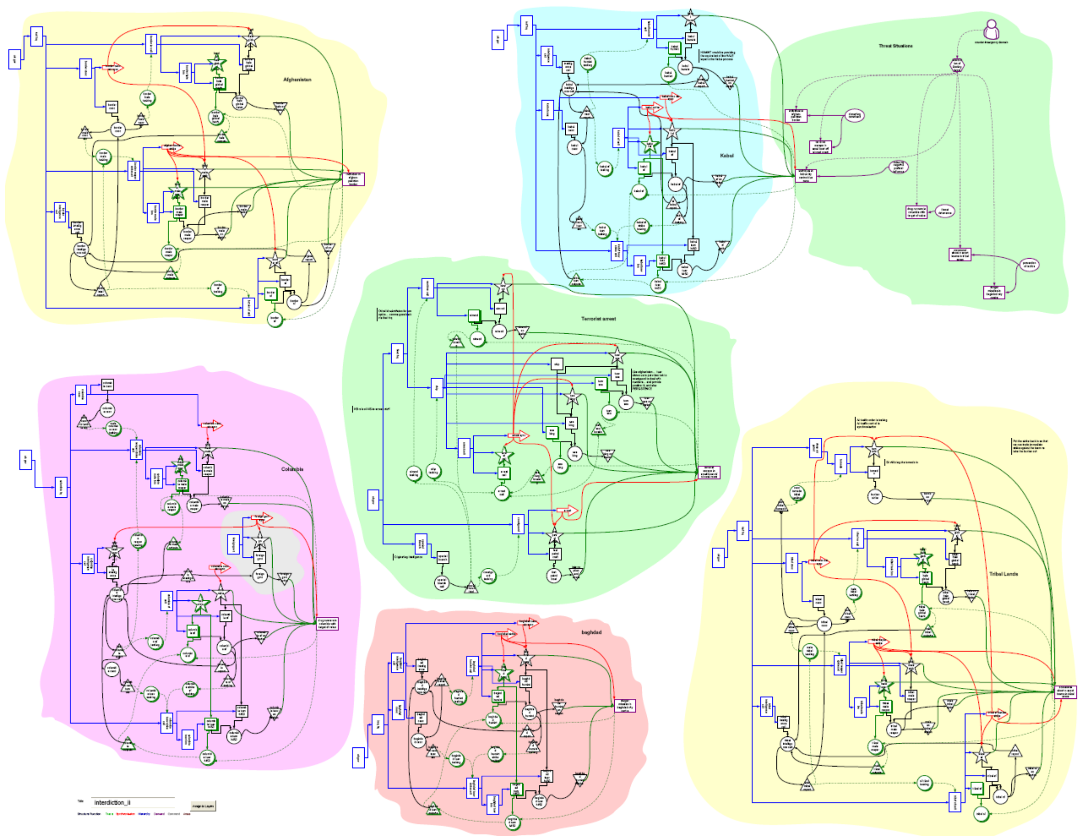

Figure 40: Models of the different UAS orchestrations

Conclusions

The resultant analysis established that the investment in UAS flexibility resulted in about a 40% total saving on the through-life cost of the missions, with about 30% of this saving coming from a reduction in the variation in through-life cost [94].

The analysis from the perspective of the multi-sidedness of demands showed how the costs of alignment could be identified independently from the costs in the use of the UAS alone. Combining both of these forms of cost analysis made it possible to unify the analyses of acquisition costs for the UAS's direct customers and the operational costs for its indirect customers. The analysis showed how the introduction of a multi-sided UAS reduced the variability in defence expenditure on these situations, adding value through the ability of the multi-sided approach to increase the agility of the force as a whole. The use of a 'real option' approach to this analysis showed how capital expenditures could secure savings in both the absolute levels of operational expenditure and in their variability. The result was a commercial basis from which to argue for the indirect value of mitigating operational costs at the time of acquisition.

Identifying Risks

Introduction

The risks of primary interest are the risks arising from errors of execution, planning and intention identified in Table 3, associated with the relationships between layers 3 to 6 in the stratification. Three projects have examined these risks, the first undertaken for British Telecom (BT), examining the ways in which their customer service systems (CSS) were used to resolve problems in the customer's use of BT's phone service. An initial study, using root cause analysis, found that 70% of errors arose from a failure properly to align product or service know-how to the complexity of the customer's context, instead allowing the CSS software to determine BT's response. A projective analysis was used to establish a stratified analysis of the way these systems were being used, establishing the presence of a structural gap between the CSS logic and that of the customer-facing adviser or engineer [156].

A second project examined the Capability Audit (CA) used by the MoD to assess the existence of capability gaps in the equipment programme, particularly with respect to the network enablement of capabilities (NEC). NEC was intended to provide agility through enabling capabilities to interoperate in new ways within systems of systems supporting new operational capabilities. A projective analysis was used to examine a campaign scenario, stratifying the way equipment was made available in theatre through force elements, which were then orchestrated in theatre to form operational capabilities. The stratification described how these operational capabilities were synchronized by command headquarters to deliver decisive moments in the campaign. Analysis of gaps in this stratification showed that the absence of a construct for orchestrations in layer 4 meant that there was no basis on which to assess the impact of NEC on the variety of orchestrations that could be formed within a deployed force. The project concluded that the absence of this construct meant that there was no way of auditing the impact of NEC on the agility of force geometry [157].

The third project was to understand and mitigate the interoperability risks facing the modernization of NATO's AWACS capability as it moved into its sustainment phase. The project found risks arising from changes in both the mission environment for the capability and in its engineering, affecting the ways in which it could be managed and adapted to new mission environments. In order to mitigate these risks, the project recommended changes to the way the components of the capability were acquired from suppliers, as well as changes in the way the operational capability itself was managed [80].

The AWACS case – identifying risks to interoperability

The NATO Airborne Warning and Control System (AWACS) capability was undergoing a mid-term modernization, introducing an asynchronous tight-coupled software architecture to replace the previous legacy system. The modernization program sat within an acquisition process that supported an operational organization facing changing operational demands on the use of the AWACS capability. The question asked by the client here was what were the medium term risks facing the operational capability in its ability to sustain its operational effectiveness, how could these risks be mitigated, and how would such mitigation impact on the acquisition process?

The problem, in this case the possibility of not being able to make effective use of the capability in the emerging threat environment, arose from the need to change the way the operational organization was able to respond to an increasing variety of demands through the way it evolved the capability.

Background

The briefing on the AWACS case identified a number of critical operational issues relating to the modernization of the capability:

- **Surveillance** – Did the modernization significantly improve the ability of the AWACS to provide an accurate recognized air and surface picture?
- **Battle Management** - Did the modernization significantly improve the ability of the AWACS to perform its control and battle management functions?
- **Flight Deck** – Did the flight deck modernization meet the AWACS operational mission requirements?
- **Maintenance** – Were the modernization improvements reliable, maintainable, and available to fulfill operational requirements?
- **Software** – Was the modernization software suitable to fulfill operational requirements?

The approach adopted assumed that interoperability was an issue across a number of different layers, ranging from the way different command authorities were able to work together collaboratively, through the way component assets and capabilities could effectively produce combined effects, down to the ability of hardware, software and firmware to work together as effective sub-systems within larger systems. The preliminary work led to a projective analysis establishing the way these levels were stratified, the visual models being built during workshop sessions attended by knowledgeable staff from different parts of the AWACS organization. This stratification was then analyzed for structural gaps across the different layers.

The software architecture

A projective analysis of the relationships between the software modules and their run-time interdependencies showed the following structural characteristics:

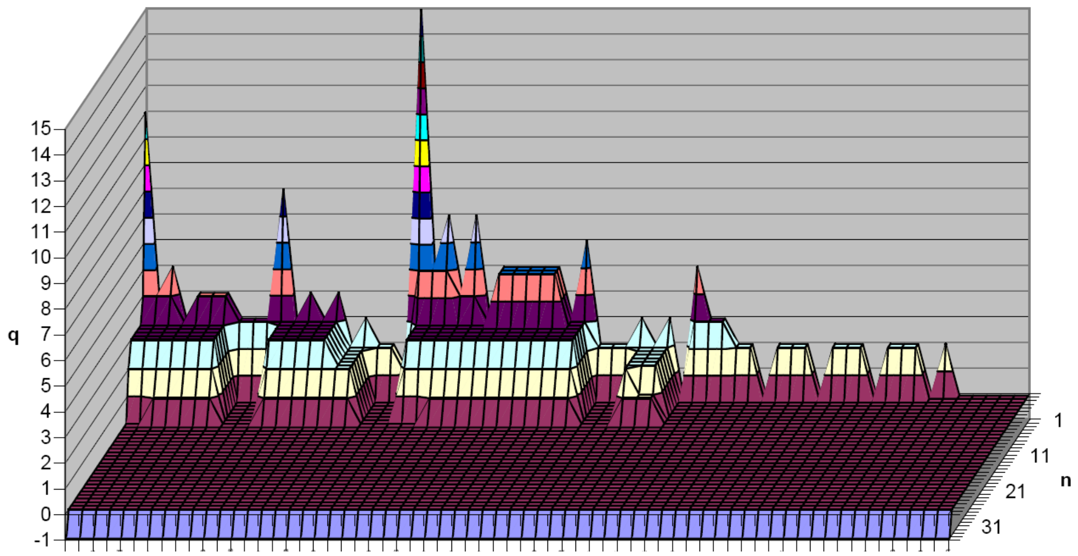

Figure 41: Software and Firmware architecture

The tallest peak, associated with the middle block of related modules, was the situation console interfacing to the operator. The two blocks to the left were the modules dealing with mission control and tracking. The peak in the separate block to the right of the situation console was the interface to the operator dealing with authorizing identification of tracks, and the remaining blocks to the right were separate sensor inputs. The broad base showed the interfaces linking all the blocks. When the dependencies between these modules were analyzed, the following picture emerged:

Table 13: AWACS software dependencies

Modules		For example	Dependencies
Core	high levels of dependency in both directions	n/a	0
Peripheral	low levels of dependency in any direction	Mission recording	23
Shared	modules depending on other modules, but not vice versa	Displayed tracks	44
Control	Modules on which other modules were dependent, but not vice versa	Sensor inputs	33
			100%

There were no significant circular (core) dependencies in the software architecture, the software having been designed to generate identified tracks from sensor inputs under a provided set of rules. The resolution of identification conflicts, with or without the use of external sources of authorization, was left to the operator. This interaction with the operators created significant performance issues.

The role of the operator

The projective analysis in Figure 42 shows a partial analysis of the way the software was embedded in the larger AWACS organization.

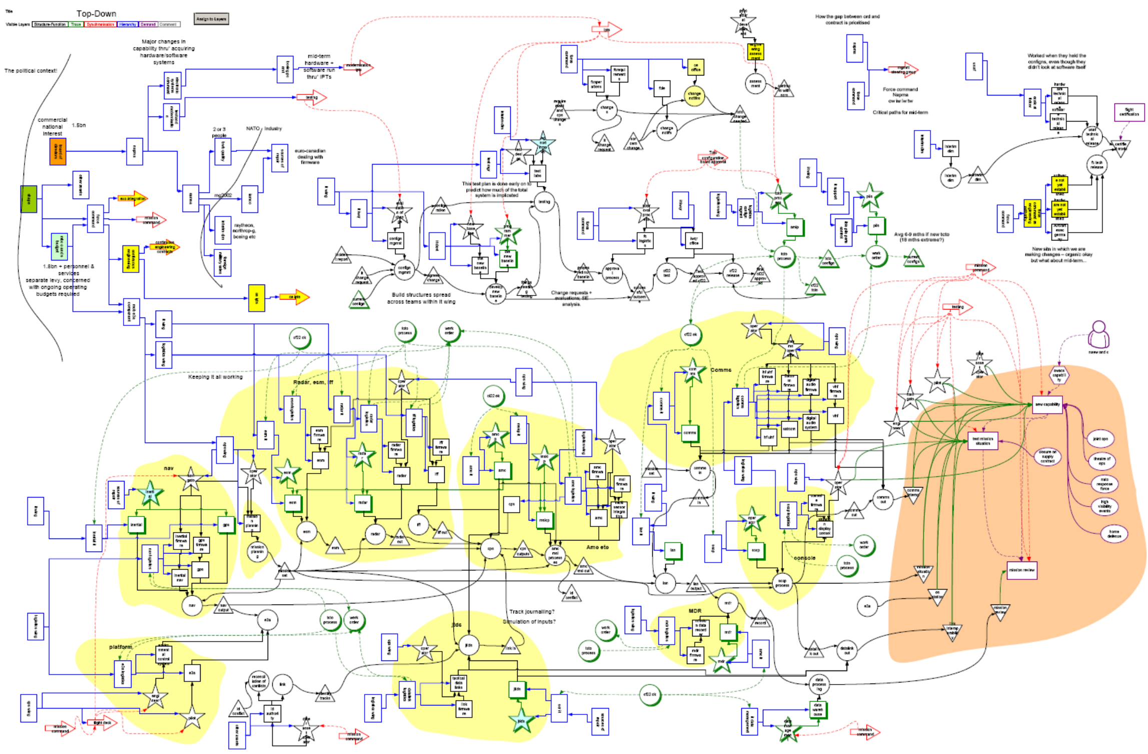

Figure 42: A Top-Down PAN Model of Aspects of the modernization

The resultant stratification matrix was used to analyze gaps at each level of alignment process, corresponding to different types of interoperability risk (the technical risks being associated with the earlier analysis of the software architecture):

Table 14: The different types of interoperability risk evaluated

Error	Type of Risk	Stratification	
Type III: Intent	Synchronization Event / Mission Demand Risks	Levels 5 – 6	Would the capability be able to deliver the performance demanded of it across its variety of mission environments?
Type II: Planning	Orchestration Risks	Levels 4 – 5	Would the internal and external component assets needing to interoperate be able to do so dynamically with the levels of performance required of them?
Type I: Execution	Customization Risks	Levels 3 - 4	Would the AWACS capability itself be able to be configured to support the forms of interoperability required of it?
Type 0: Construction	Technical Risks	Levels 2 - 3	Would the constructed capability be able to perform according to its original design specification?

Something of the complexity of the AWACS capability could be seen in the analysis of the layer 1-2 activity chain relationship in Figure 43. The tall peak on the left was the role of the operator, supported by the software, but spanning a high level of operational complexity alongside large numbers of separate components.

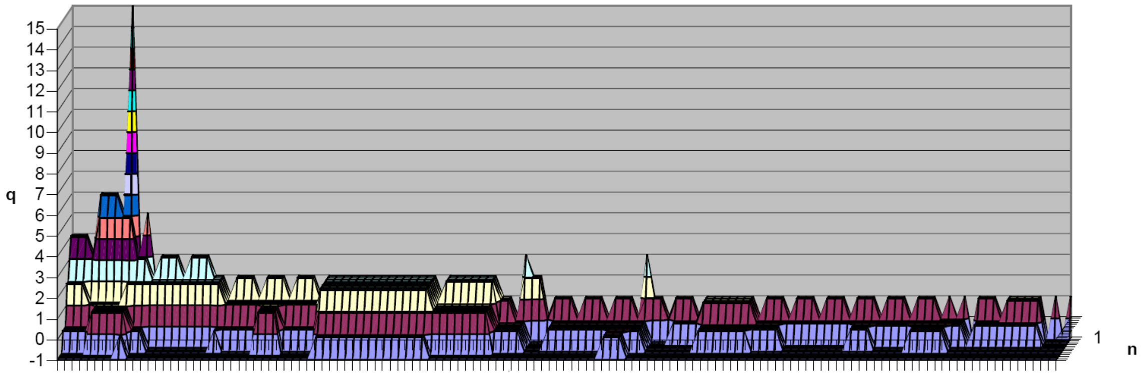

Figure 43: Landscape analysis of layer 1-2 activity chain relationship in the stratification matrix

In the layer 5-6 synchronization relationship (Figure 44), the tall peak is again the operator, this time synchronizing systems in the lower layers in support of mission command, including interoperation with other assets. The operator was critical in binding together the complexity across all the layers of the stratification.

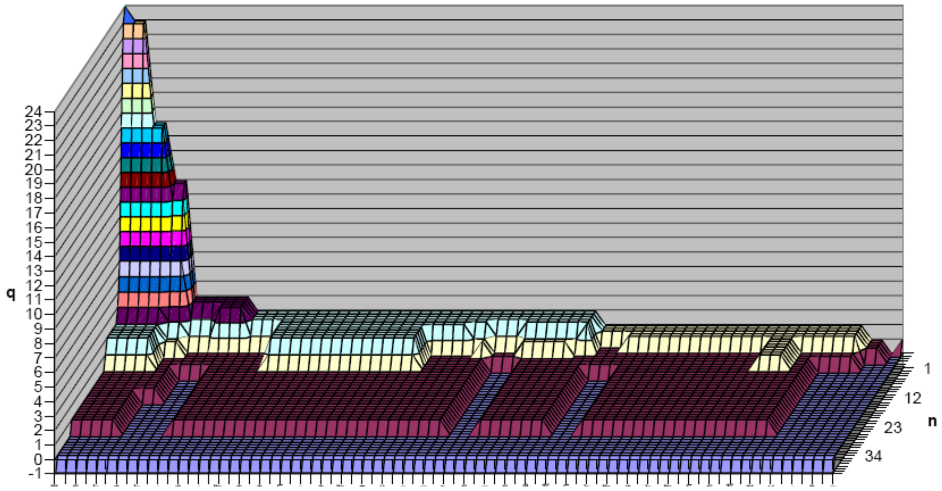

Figure 44: Landscape analysis of layer 5-6 synchronization relationship in the stratification matrix

A closer look at what was being bridged by the operator in the layer 4-5 orchestration relationship (Figure 45) shows the gaps between the high peak on the left (mission command), and on the right (communication links). The jaggedness in between was the gaps between different sensor inputs, track reconciliation and the resolution of identity conflicts. The modernization of the software was to reduce the load on the operator in bridging these gaps. In practice, however, this depended on well-defined rules for track identification. This could not be assumed in the changing mission environment.

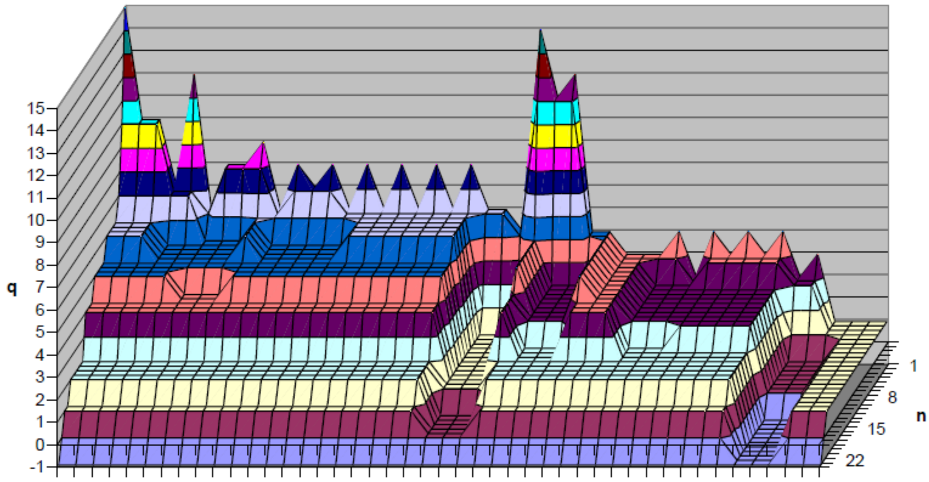

Figure 45: landscape analysis of the layer 4-5 orchestration relationship in the stratification matrix

The challenge to organization

The complexity of operating the AWACS capability in differing mission environments alongside other force capabilities was carried by the operator, supported by the ways in which track identification could be automated. An initial analysis of three such differing mission environments, however, established the extent to which this introduced variabilities into both the way the supporting systems would need to be used, and also the extent to which significant interoperation would be needed with other force capabilities. The demands presented by these mission environments was represented in Figure 46 by the position of the yellow customer situations within their effects ladders. In effect, the uses of the AWACS capability were diverging more and more from the contexts established by its original requirement.

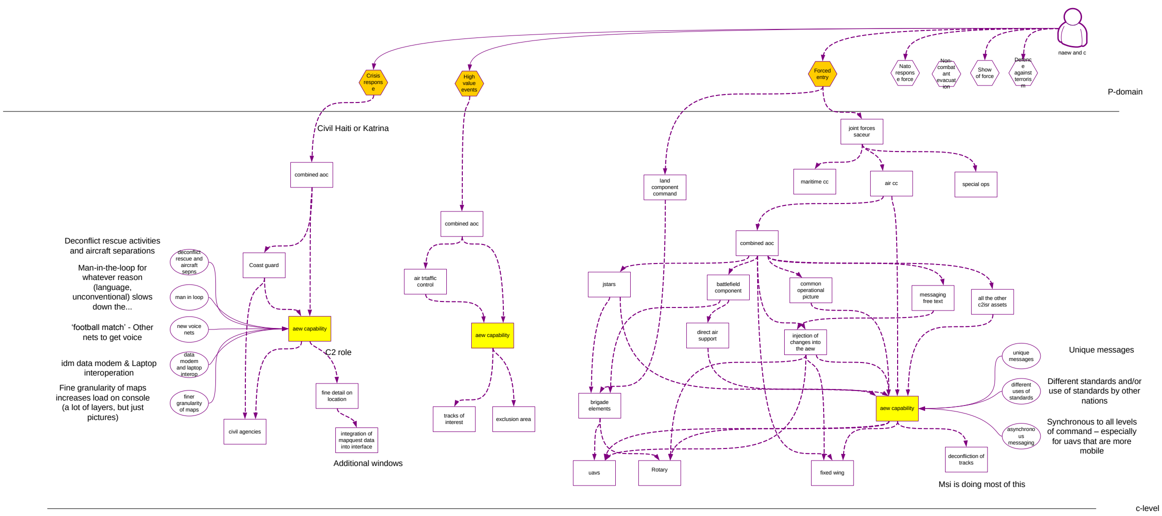

Figure 46: An effects ladder across three different types of mission environment

Significant risks arose, therefore, from the ability of the organization to align the underlying capabilities to the changing operational requirements. Sitting over the operational capability were two distinct hierarchies: an operational hierarchy (the peak on the left in Figure 47), and an acquisition hierarchy (the much lower peak on the right).

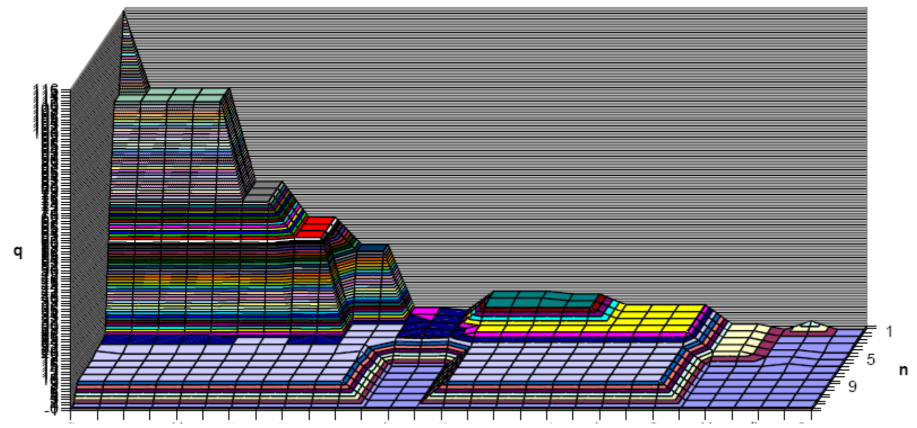

Figure 47: Landscape analysis of the operational and acquisition hierarchies

This evidenced the stratification from the preliminary analysis, shown in Figure 48, in which an acquisition organization in layer 1 was supplying the AWACS operational asset; and the AWACS operational asset was then being made available by the operational hierarchy spanning layers 2 and 3 for use by Force Command in defined mission situations:

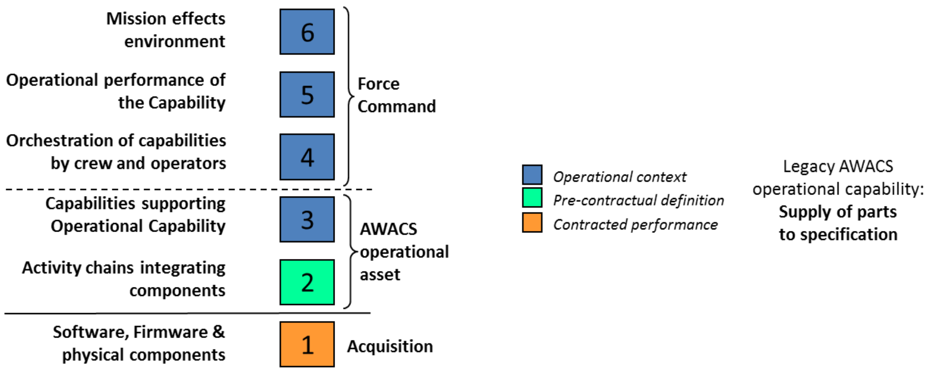

Figure 48: The legacy AWACS operational capability

This organization reflected the traditional arms-length relationship between suppliers and the domain of operations. Significant risks arose from this separation of these hierarchies and the different criteria and timescales on which they worked, the separation making it very difficult to manage acquisition on the basis of continuous engineering disciplines supporting evolving operational requirements. An immediate change proposed, therefore, was to move the contractual boundary to a maintenance and supply organization that could apply a continuous engineering approach to the through-life availability of components across layers 1 and 2 (shown in the left-hand column of Figure 49).

Analysis of the operational hierarchy also showed the extent to which it compounded the dependencies on the operator by not being able to support the continuous adaptation of the AWACS capability to changing operational demands within the changing mission environment. A further change was proposed, therefore, to the way operational accountability for the performance of the AWACS capability was defined, making needed changes in force collaborations the basis on which Force Command tasked the AWACS capability. In this way the AWACS capability became responsible for the processes of architecture management needed for its continuous re-alignment to changing operational demands, i.e. for securing the multi-sidedness of the AWACS platform [81]. Although those responsible for the AWACS operational asset had been trying to do this before, this had been despite the operational hierarchy with its separate acquisition organization, resulting in significantly greater expenditures in ways that paralleled the UAS case. This second change in organizational alignment is shown in the right-hand column of Figure 49.

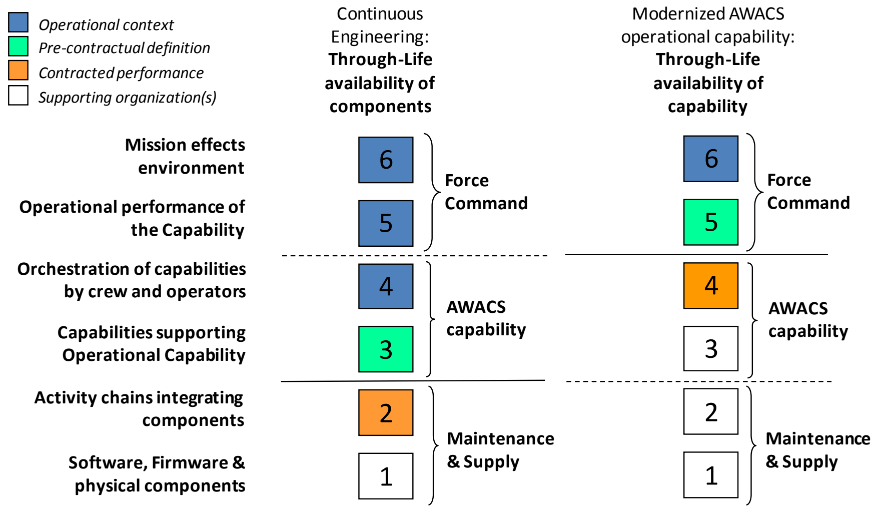

Figure 49: The re-alignment of the organization to support continuous re-alignment of the capability

Conclusion

Significant medium term risks faced the operational capability in its ability to sustain its operational effectiveness, the mitigation of which depended on adopting a different approach to the role of the software as well as changing the organization and its relationship to the acquisition process. Projective analysis provided a means of identifying the risks at different layers of the stratification to making effective use of the AWACS capability in the emerging threat environment. The analysis was able to show how these risks could be mitigated by changing the way the operational organization could respond to an increasing variety of demands through the way it was able to evolve the capability. Further work was proposed to define the changes needed to enable the architecture of the software platform itself to support indirect demands, acting in concert with other operational assets.

Defining characteristics of platform architecture for mitigating risks

Introduction

The AWACS case identified risks arising from the way the organization was not agile enough to be able to align underlying capabilities to supporting the variability of indirect demands anticipated in a changing mission environment. The ability to mitigate these risks by reorganization was constrained by the interests of existing stakeholders, but could be achieved relatively quickly. Mitigating risks arising from a lack of flexibility in the underlying software platform posed a much more serious challenge. Three projects examined the mitigation of constraints imposed on agility by both organization and software architecture.

The first of these examined the means by which 'best-of-breed' software tools and systems could be made available to the user communities managing wildland fire [158]. The project observed that the greatest obstacle to aligning the available systems to the increasing scale and variety of Wildland Fires was the community's lack of focus on the forms of collaboration needing to be supported, both organizationally and technically. The project used projective analysis to identify the architectural characteristics of the best exemplars of systems of systems supporting collaborative working. It recommended that there needed to be a focus on service oriented architectures and on the technical challenges of data fusion across the datasets, tools and models being used by the community [159].

The second project examined the potentially transformational impact that a supercomputing network [160] could have on the way scientific research was conducted within the context of a national Science Foundation (NSF) research programme [161]. The project used a stratification approach to consider the architectural issues raised as the focus switched from networking computing capabilities to the demands associated with supporting particular research communities [135].

The third project examined the provision of orthotics care within the NHS, making recommendations on both the organization of the clinics and on the data platforms used to support a changed way of working [4]. Six pathfinder projects were used to test both recommendations, the levels of savings generated being shown to be four times the initial cost of the changes [5]. The key role of the data platforms was to provide the multi-sided support needed to enable the clinicians to manage patients' conditions on a through-life basis. The architecture of the platform was designed to bridge existing gaps in the data to make this possible [97].

The Orthotics case – defining the platform needed to support clinics

The National Health Service's policy objective for the Orthotics Service was to significantly increase the quality of its services to patients nationwide, through reducing the systematic under-use of orthotics treatments. The means of achieving this outcome was to better align the services of orthotics clinics to the needs of their patients through the life of their condition. To make this a sustainable change, data platforms were needed to mitigate the risks associated with managing the much greater complexity of delivering services on a through-life basis. The question asked by the client here was how would the use of a data platform impact on the way a through-life service could be provided?

The problem, in this case the current under-use of the service, arose from the difficulties of holding orthotists' practices accountable on a through-life basis for the costs of managing their patients' conditions.

Background

A projective analysis of orthotics service provision was used to capture the characteristics of the collaboration needed between the clinician, the other clinicians involved in the patient's treatment, and the supply chains being used to support the clinic (Figure 50).

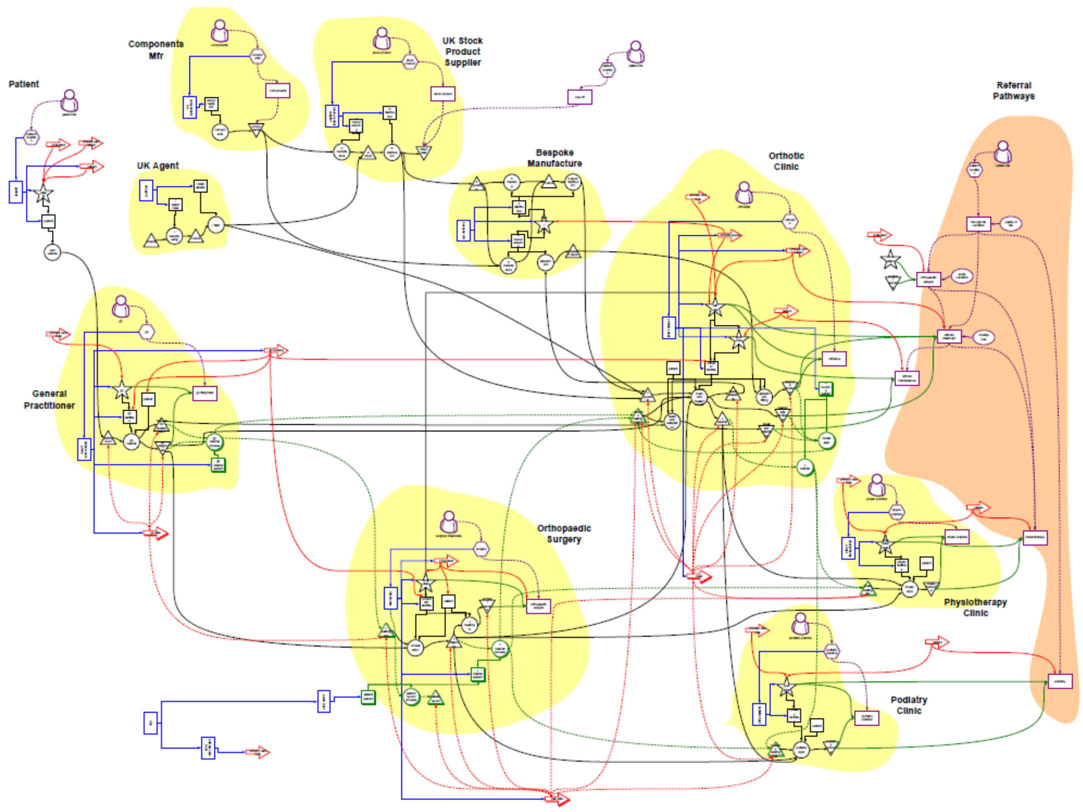

Figure 50: a projective analysis model of orthotics service provision

Through-life management of the patient's condition involved the orthotist being able to see how the activity chain supporting a single episode could be varied as the patient's condition developed over time. Figure 51 shows the landscape for this activity chain with two main types of gap. The first of these is with the manufacturing processes on the right of Figure 51, typically managed by data platforms provided by the manufacturer. The second is with the diagnostic and clinical processes on the left of Figure 51, between which there were significant gaps.

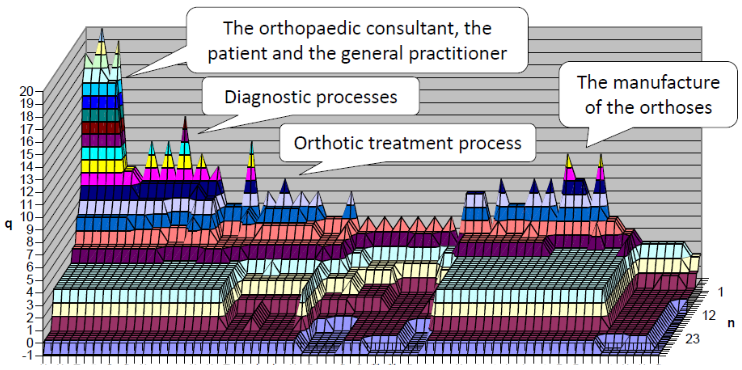

Figure 51: landscape analysis of the layer 2-3 activity chain supporting the orthotics clinic

These gaps are shown in Figure 52 between both the orthotic data supported by the manufacturer and the Trust, but also with the data held by the primary care physician. Data relating care pathways to patients' conditions was entirely absent, with the data on patients' treatments being related to appointments and not to the cumulative cost of multiple episodes of care. Mitigating the risks to sustaining through-life management of patients' conditions therefore depended on making a data platform that could bridge between the existing sources of information.

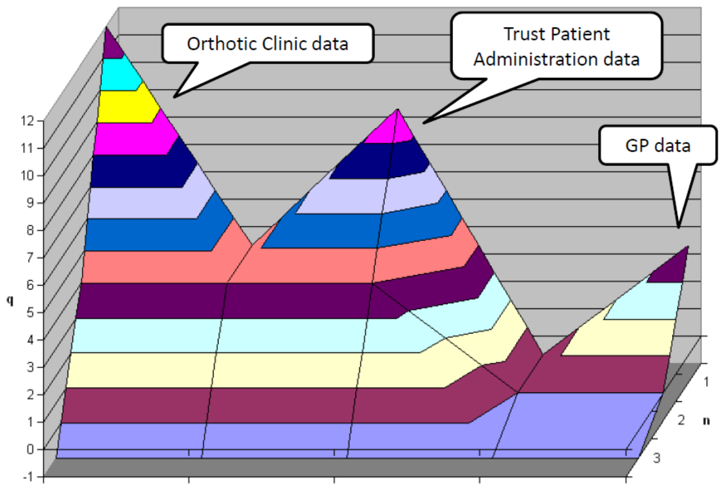

Figure 52: structural gaps between data platforms

A detailed projective analysis of the forms of data fusion needed was then used to define how to bring these different sources together in a way that was relevant to the orthotic clinician's management of their patients' conditions.

Conclusion

Mitigating risks in the orthotics case involved both organizational changes and changes in the systems supporting the clinics. The organizational changes involved re-negotiating clinical relationships in order to be able to focus on patients' through-life conditions, which included changes to the methods by which orthotics services were commissioned. None of these changes were sustainable, however, without corresponding changes to the way data platforms were used to support the more complex collaborations needed between clinicians.

Table 15 summarizes the corresponding shifts in focus needed from direct to indirect customers in each of the case studies in this section, and the multi-sided platform needed in each case to support the corresponding indirect demand situations.

Table 15: Summary of the organizational shift in focus from direct to indirect customers with the platform needed

	Project	Direct Customers	Multi-sided platform	Indirect customers
Quantifying Indirect Value	MoD surface capability	MoD acquisition	C4ISTAR platform	Mission Commanders
	Swiss eGovernment	Federal Chancellery	Search engine platform	Respondents to citizens
	UASs	Royal Artillery	UAS platform	Mission Commanders
Identifying Risks	BT customer service	Area management	Customer services platform	Phone user
	NEC	MoD acquisition	Capability systems of systems	Mission Commanders
	AWACS	NATO acquisition	Mission systems of systems	Mission commanders
Mitigating risks	Wildland Fire	Federal Agencies	Collaboration support	Fire fighters
	XSEDE	Supercomputing centers	Research systems of systems	Research collaborations
	NHS Orthotics	Healthcare Trusts	Clinician support platform	Patients

Chapter 6 - Implications

This thesis has shown how creating indirect value requires of suppliers that they change the frame of reference within which they define value, to include the varieties of indirect customer situation in which they are implicated. This change involves being able to recognize the sovereignty of any given indirect customer over the particular way the indirect customer's identity is supported by the alignment of products and services to their indirect demand.

It follows from this that suppliers must be able to accept some degree of limitation on their own sovereignty in responding to indirect demands. As a consequence, the modeling of suppliers' relations to indirect customers' demands must be triply articulated if it is to represent relationships between multiple forms of sovereignty. Suppliers need this triply articulated modeling if they are to model and analyse the characteristics of the ecosystems linking them to the perspectives of direct and indirect customers. Suppliers must also be able to create ecosystem platforms capable of sustaining new kinds of multi-sided relationships in cooperation with their direct and indirect customers [162].

Suppliers therefore face considerable challenges in taking up the third asymmetry as a basis of competitive advantage. The extent of this challenge can be seen from a recent article asserting that "companies are widely perceived to be prospering at the expense of the broader community" [163]. The authors went on to say:

> "A big part of the problem lies with companies themselves, which remain trapped in an outdated approach to value creation that has emerged over the past few decades. They continue to view value creation narrowly, optimizing short-term financial performance in a bubble while missing the most important customer needs and ignoring the broader influences that determine their longer-term success. How else could companies overlook the wellbeing of their customers, the depletion of natural resources vital to their businesses, the viability of key suppliers, or the economic distress of the communities in which they produce and sell? How else could companies think that simply shifting activities to locations with ever lower wages was a sustainable "solution" to competitive challenges? " [163] p4

Creating the forms of indirect value described in this thesis is one way of creating shared value: creating indirect value creates value for the supplier, but it also creates value for the customer in a way that is rooted in the indirect customer's context of use, supported explicitly by the supplier. One of the authors of the article is Michael Porter, who is more identified than anyone else with the framework of analysis that gave rise to the problem described in the quote above [108, 109, 164]. He began to question companies' approach to value creation towards the end of the 90's [104], but why did he decide to go so far as to argue that the purpose of a corporation should be re-defined as creating shared value, not just profit per se? It follows from this thesis that this would be necessary if a supplier chose to add the third asymmetry to the way it competed because of the extent of the re-frame demanded.

Should a supplier choose to take up these challenges, then this thesis has established a frame of reference within which the supplier can consider the relationships between multiple forms of sovereignty expressing different identities within their ecosystem, what forms of architectural agility become necessary in creating value in relation to these different identities, and how to consider the balance between the risks and benefits of such a strategy that includes competing on all three asymmetries. What the thesis has not considered, however, are

i. how a supplier can manage such a change;
ii. the consequences for the economy should such changes occur on any scale;
iii. how these changes extend to the engineering of the platforms themselves; and
iv. the mathematical and pragmatic implications of such a change.

In each case, further work is needed beyond the continuing development of the uses of the frame of reference and the associated methods of analysis themselves.

How a supplier can manage such a change

Even though there is benefit to be gained by a supplier from surrendering aspects of their sovereignty, it is not an easy change to make. Assuming that a platform architecture can be developed that will deliver added value, there has to be delegation of authority to the edges of the organization, new forms of horizontal accountability have to be established, and leadership from the top has to focus on the sustainability of an organization that is continuously adapting itself to changing indirect demands. At the heart of these processes is the ability to shape the development of the ecosystem within which the supplier is competing, which can no longer be done in the interests of the supplier alone [10]. The continuous processes of learning and adaptation required of the supplier demand an internal economy of discourses that can sustain a requisite variety of supplier behaviors commensurate with that being demanded by the larger ecosystem [40]. This internal economy cannot depend upon sovereign leadership alone, depending as it does on learning from the responses of individuals to demands at its edges. So how is this learning to be organized? To manage change, the internal economy must overcome resistance to change based on the way individuals have chosen to use the supplier's task systems in support of their individual identities. The internal economy of discourses constrains what can be performative for the supplier[165], and the thesis has not addressed the much richer understanding needed if these constraints are to be changed in response to changing circumstances.

The consequences for the economy should such changes occur on any scale

Globalization has already moved much production to developing economies, while the Western economies have become increasingly organized around services. The arguments for a support economy aligned to the experiences of individuals [8], together with arguments for businesses to give prime importance to creating shared value [163], point to an economy already competing on the basis of the third asymmetry, particularly if the service sector is understood to be about creating economies of alignment in post-industrial economies [166]. But what happens to the quality of life under these conditions? A working paper published under the auspices of the IMF showed how extreme differences in the distribution of wealth within an economy induced instability in its performance [167]. New forms of governance will be needed to balance between the interests of the few and of the many within an ecosystem if all are to be treated with equal concern and respect [168]. The thesis has not considered the ways in which the differing interests of stakeholders can be balanced within an ecosystem focused on creating indirect value.

How these changes extend to the engineering of the platforms themselves

A platform architecture makes new kinds of demand on the engineering of the supporting systems of systems, which have to be collaborative. Current approaches to engineering systems start from the functional and non-functional requirements of a customer, and then design a system that delivers against those requirements. These approaches assume a separation between the supplier-developer and the customer-user, separating design-time from run-time. This separation is no longer possible in the collaborative environments within which indirect value is being created, the run-time characteristics of collaborative systems of systems creating an entanglement between developers', stakeholders' and users' views necessitating an ecosystem perspective within which to work to resolve potential inconsistencies and to identify potential risks [123]. Thus while the closures of the behaviors of individual system components may be deterministic, the closures of the behaviors of collaborative systems of systems must be non-deterministic if their local behaviors are to be made deterministic by the way any particular collaboration chooses to impose constraints on their use. In this more complex environment, transactional systems and systems of record must interoperate with systems of engagement supporting the collaborations themselves [169]. The methods of analysis put forward by this thesis can identify the structural characteristics of these systems of systems and their interoperability within the context of the ecosystems using them. What the thesis has not addressed is the means of establishing semantic interoperability between systems where the semantics themselves vary with respect to the demand-side pragmatics of the contexts-of-use.

The mathematical and pragmatic implications of such a change

The thesis identifies three forms of asymmetry that follow from incommensurabilities in the way a particular supplier sustains its relation to indirect demands. The forms of discretion through which the supplier resolves indeterminacies in its behavior require that both the chronos axis of succession and the kairos axes of moment are modeled, with the kairos axes being modeled in relation to the nature of different forms of indirect demand. This modeling represents the actual behavior of the supplier as a trajectory in its model space, passing through a plane of simultaneity from its past into its future, with the extent of the non-determinism in closure of the supplier's behavior being represented therefore as a light cone [170].

This parallel with the physics of general relativity is based on a representation of a discrete and not a continuous model space, while the parallels with the physics of quantum theory are between the three asymmetries and the Cartesian (model-of-behavior), Heisenberg (sentient) and endo-exo (value) 'cuts' in quantum theory [171, 172]. The frame of reference put forward by this thesis provides a way of understanding the entanglement and complementarity between the asymmetries in the way a supplier defines them with respect to each other within a given ecosystem [173], viewing any given supplier as engaging in a particular form of symmetry-breaking, for example in the healthcare case [97]. The structure of a C*-algebra seems to be adequate for representing the underlying model of triple articulation, in which there are two kinds of relation defined by the mappings between the articulations, between vertices and edges, and between height and depth, and in which there are two kinds of time – chronos and kairos [174]. What are being represented here are the structures of triple articulation, with the probability distributions generated by using

Monte Carlo methods being an approach to quantifying the behavior of these structures. These implications of the method have yet to be pursued.

Defining indirect value involves qualifying the meaning of the supplier's behavior within the context of the indirect customer's context-of-use [87]. This is consistent with a pragmatic approach to the semantics of the supplier's behavior [175], the background influence on the thesis of Lacan's work suggesting that the particular way in which pragmatics should be understood is pragmaticist in its approach, drawing on Peirce's notions of thirdness [176, 177]. This pragmaticisit approach implies that there can be no ('design-time') universal position from which the performance can be optimized, other than one which is universal only with respect to a particular context-of-use. Rather there can only be a continuous ('run-time') process of change driven by responding to the structural flaws in the existing ecosystem with respect to any given emerging interest. A pragmaticist formulation of the basis of the frame of reference might provide insight into the difficulties suppliers have in moving to it from the sovereign perspective of a supplier defining its markets, but the thesis has not addressed these implications for the theory of meaning underlying the frame of reference it has put forward.

Appendices

Appendix A – Defining the multi-sidedness of a platform architecture

Supporting the multi-sidedness of indirect demands

In order to create indirect value for its indirect customers, a supplier must identify indirect relationships that it can support in such a way as to reduce the indirect customer's externalities. Externalities are the costs incurred by indirect customers related to their use of a service but not included in the economics of the direct service itself. In the case of using the Nokia phone, the externalities were the costs of alignment incurred by the phone user associated with organizing a blind date, and involved the time spent organizing and linking the various activities associated with identifying a nearby restaurant, making a booking, text messaging the details to a friend, and putting the details in a diary. The indirect value of the smartphone comes from the way it reduces these externalities [178-180], with smartphones competing to reduce an indirect customer's alignment costs by moving some of the indirect customer's externalities onto the smartphone platform [181].

If we consider the smartphone ecosystem, then the direct relationships that Nokia has with the service provider (its direct customer) is to enable the service provider to provide its customers (Nokia's indirect customers) with a telephone, a messaging device, or a means of interacting directly with the internet. The indirect relationships arise from the interactions between these uses of the device and other uses based on applications provided by 'complementors', in which the service provider itself becomes one of the complementors. These complementors provide services and applications that interact with indirect customers' uses in ways enabled by the smartphone platform but that are not possible with the Nokia device [182]. The indirect customer's externalities are therefore greater from using the Nokia than from using the smartphone platform.

These distinctions are shown in Figure 53. The platform provides support to direct relationships with complementors, including the service providers, and to indirect relationships between complementors and the supplier's indirect customers on the smartphone platform. From the perspective of the supplier, while the direct value flows from the direct relationships it has with the complementors, the indirect value flows from the way the indirect relationships enable the indirect customer to reduce the externalities of responding to indirect forms of demand (for example organizing a blind date rather than just making the calls).

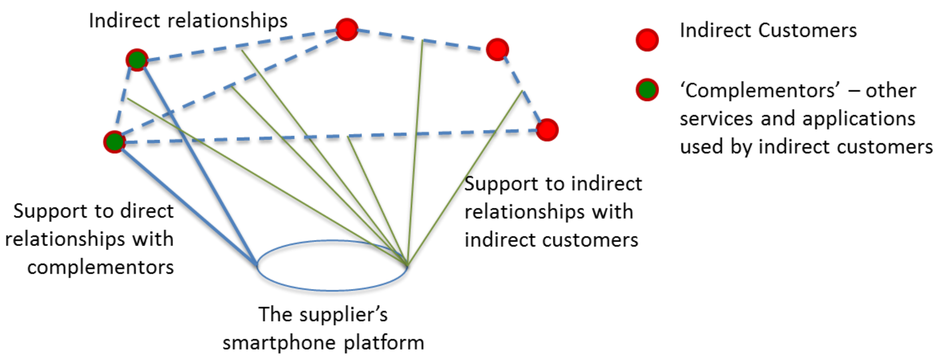

Figure 53: Supporting direct and indirect relationships

From the perspective of the supplier, these indirect relationships create multi-sided demands, with its platform supporting both direct and indirect relationships making it a multi-sided platform. A multi-sided demand is one in which a supplier needs distinct groups of (indirect) customers and complementors who value each other's participation on board the same multi-sided platform in order to generate value, and in which the indirect value to the supplier of the indirect relationships are at least as important as the direct value of the direct relationships [182, 183]. This is in contrast to one-sided demands in which suppliers serve different types of direct customers, but not in ways that include the indirect interactions between the different types of customer. Thus in the smartphone case, the smartphone is the platform and the complementors are the suppliers of applications that interoperate on the platform to support the composite activity of organizing a blind date. The multi-sided demand is created by all the different forms of indirect demand that the indirect customers can make in the use of the smartphone. In the UAS case, the platform is the UAS enabling indirect interactions between the different capabilities involved in a mission. And in the orthotics case, the platform is the clinic enabling indirect interactions between multiple clinical specialisms in support of the patients' through-life conditions.

Defining the multi-sidedness of a platform architecture

The role of a supplier's platform in supporting multi-sided demands can be summarized in terms of its participants and the relationships between them. The platform's participants can be divided between indirect customers using the combined performance of indirect relationships forming a collaboration supported by the platform, and complementors making particular functionality available on the platform to be taken up for use by their direct customers, who are the supplier's indirect customers, each complementor with its own supply-chain for making its functionality available on the platform. The complementors and different types of indirect customer on a supplier's platform together are part of an ecosystem of operationally and managerially independent economic entities co-creating value, with the platform supplier occupying a key position [114].

An indirect customer situation creates a particular indirect demand, in response to which the indirect customer puts together a set of relationships between platform participants. The particular set of relationships between indirect customers and complementors that are supported by the platform define a geometry-of-use of the underlying products and services, shown in Figure 54:

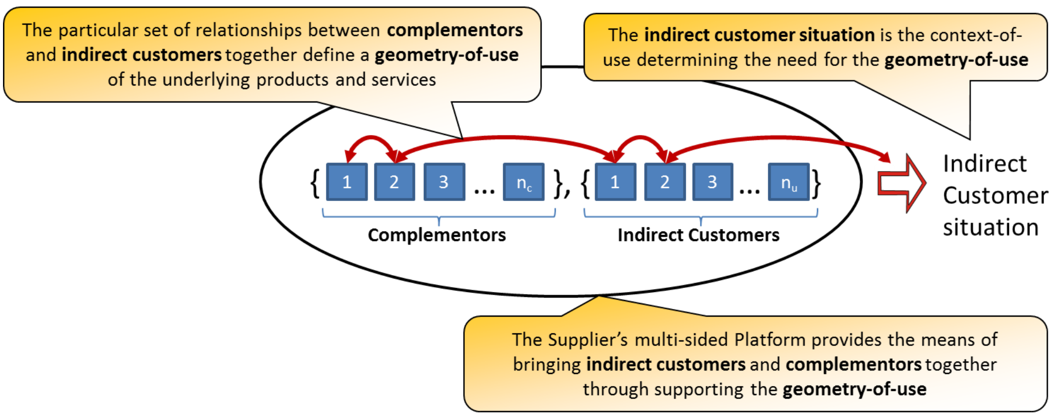

Figure 54: A geometry-of-use supported by a multi-sided platform

Although there may be very large numbers of possible sets of relationships between all the indirect customers and complementors using a multi-sided platform, there will be a limited number of these orchestrations that can be supported by the platform, each instance of which becomes a particular synchronization of that geometry-of-use in a particular operational situation in a way that meets the particular timing characteristics of the situation. The multi-sidedness of the platform will depend on the nature of the indirect customer situations with which its use can be synchronized, supported by some variety of orchestrations. The role of the platform in the lives of its indirect customers will therefore be limited by its agility, defined as the variety of orchestrations that it can support within a given time-frame. Whether or not the platform prospers will then depend on the economics of the indirect benefits it creates in the lives of its indirect customers.

Table 16: The roles of direct and indirect customers on multi-sided platform architectures

	Nokia	iPhone	UAS	Orthotics
Supplier	Nokia	Apple	Thales	Orthotics supplier
Multi-sided Platform	-	iPhone+Cloud	UAS	Orthotics clinic
Direct Customer	Service Provider	Service Provider*	Royal Artillery*	Clinician*/**
Supporting geometry-of-use	In the ability of the phone user	In the linkages between user's apps	In the linkages between capabilities	In the linkages between clinicians' treatments
Indirect Customer	Phone user**	Phone user**	Mission commander**	Patient
Indirect Customer Situation	Arranging a blind date	Arranging a blind date	Interdicting a fleeting target	Managing a patient's chronic diabetic condition

* - takes up role of a complementor on the multi-sided platform ** - leads the collaboration supported by platform

These distinctions are summarized in Table 16 for each of the cases. Where the supplier creates a multi-sided platform to provide support to the indirect customer situation, the direct customer becomes a complementor on the platform. The leadership of the collaboration between indirect customers and complementors supported by the platform may remain with the indirect customer (for example in the UAS case) or move to the direct customer (for example in the Orthotics case). For the Nokia case, the geometry-of-use supported is in the ability of the phone user to make linkages between the various activities himself or herself. For the other cases, the technology of the platform itself supports these linkages.

Appendix B – Constructing models of ecosystems

Modeling the socio-technical business ecosystem associated with the iPhone shows one of the problems in dealing with ecosystems – the problem of finding the boundary. What is the "boundary" of the iPhone ecosystem? The iPhone uses the cellular network as a carrier, so must any analysis of the iPhone include the cellular system, which in turn requires uninterruptible power, and so on? Defining the technical boundary can be solved by starting from the behaviors that the modeler is interested in explaining. The boundary is then defined by those systems that cause those behaviors [184].

This deals with systems for which there are well-defined models explaining their behavior, as well as systems in which emergent behaviors are encountered through inadequacies in the modeler's knowledge of how its elements are interacting. But given that people are considered to be part of the ecosystem, it cannot be just hardware. Again, many people use the iPhone, so must they all be considered when analyzing the iPhone ecosystem? And must the modeler also consider the people who have influence over the organization of the cellular network? Again the boundary problem can be solved by reference to the behaviors that the modeler is interested in explaining, but now with respect not only to the interactions between the elements of a system, but also with respect to those with influence over the way its use is or may be organized. From the perspective of leadership within an ecosystem, these are potentially 'wicked' environments [185], and the way these interactions can be defined have a significant influence on the possible modeling approaches through which it is possible to decide how to act. Paraphrasing from [186], we can usefully distinguish the following:

- *Simple* and *complicated* contexts, in which an ordered ecosystem is assumed, where cause-and-effect relationships are perceptible, and right answers can be determined based on the facts.
- *Complex* and *chaotic* contexts, in which the ecosystem is unordered, and there is no immediately apparent relationship between cause-and-effect, and the way forward is based on emerging patterns.

As is argued in the TRADOC pamphlet on Commander's Appreciation and Campaign Design [187], wicked environments present the modeler with unordered behaviors. In these environments, models are in the first instance hypotheses that the modeler must construct through abductive processes, based on the best knowledge and experience available. It is for this reason that the process of modeling in these environments is referred to as *projective analysis* – the analysis by the modeler of their abductions based on the best knowledge and experience available. The analysis of an ecosystem is referred to as a *projective analysis* because of the dependence of any model produced on the particular interest of the modeler(s).

Resolving the boundary problem

The solution to the boundary problem when analyzing an ecosystem is therefore to make explicit three aspects to the way the modeler(s) bound the system of interest, based on the three asymmetries in Figure 5:

(1) the domain of interactions with respect to which the analysis should be conducted,

(2) the supply-demand relationships in terms of which direct and indirect value is being generated that are of interest to the modeler(s), and
(3) the way models are being imposed on the relationships between supply and demand.

For example, a user interested in using the iPhone ecosystem views these aspects differently to a cellular system administrator, as outlined below:

Table 17: Three aspects of the modeler's interest bounding the modeler’s analysis of an ecosystem

Aspects bounding the analysis of the ecosystem		A user of the iPhone within a business	An administrator of an cellular network service provider
1	Domain of interactions	Uses of the iPhone relevant to the user’s work	All possible interactions across the cellular network
2	Supply-demand relationships	Accessible cellular networks	Accessible cellular and land networks
3	Models	The way the user manages their access to and use of the iPhone	The way the security, access to and availability of the networks are managed

Projective analysis must enable the modeler to construct a model of the ecosystem from which conclusions can be drawn on the agility of a supplier responding within the ecosystem to indirect demands. These conclusions need to be based on analysis that can provide insight into the dependencies, architecture, risks and economics associated with generating particular behaviors. An overview of what is and is not considered is as follows:

- Entities within an ecosystem are defined as economic units. This does not assume that value is necessarily measured in terms of monetary value, but that the interests of such entities are independent while shared interests are explicitly modeled.
- An ecosystem is modeling through the relationships between resources, task and organization. Thus the model identifies economic entities, their activities, and the kinds of relations among them and their activities. But the model does not model the behavior of the dynamic interactions between resources, tasks or organization.
- Modeling an ecosystem requires the modeler to make their interest in the behavior of the ecosystem explicit. This interest affects both the way things are looked at (including meanings attributed), and the substance of what is of interest – what gets brought into the foreground by the modeler against a background of unlimited complexity [188].
- Each economic entity within an ecosystem uses a collection of task systems. These are the architectures and activities within the entity (or under contract to the entity) through which it produces outcomes. The choice of which task systems to model, how and at what scale they should be modeled, are again dependent on the interests of the modeling process.

Scoping the interests of the modeling process

An analysis of an ecosystem starts from an interest in the way particular forms of value are created within the ecosystem – value on the demand-side rather than the supply-side [9]. For healthcare, the value is in the way patients’ conditions are treated. These forms of value arise within specific contexts, giving rise to indirect demands in this case on the orthotics service. In scoping the analysis of an ecosystem, the analysis has to be bounded in terms of the relationship between these indirect demands, the direct demands they give rise to on suppliers, and the activities of the entities through which these demands are ultimately satisfied. This scoping therefore starts with defining the relevant effects ladders giving rise to indirect demands. The varieties of outcome that respond to these indirect demands are then analyzed in terms of the underlying multi-sidedness of demands they generate on suppliers. Finally the three aspects of the modeler's interest are implicit in the overall relationship between suppliers, outcomes and effects ladders. These preliminary analyses are summarized in Table 18, and described in the following sections.

Table 18: Types of preliminary analysis

Type of analysis	What it is	When it can/should be used	Outputs
Effects ladder	An analysis of the effects on a stakeholder's domain of satisfying particular contexts-of-use	Used to understand the organization of a particular stakeholder's demands, and their relation to indirect value	A visual representation of the way a stakeholder's domain decomposes into individual contexts-of-use giving rise to particular indirect demands
Multi-sided demand	An analysis of the way outputs within the ecosystem are combined to satisfy particular indirect customers' contexts-of-use	Used together with the effects ladder to understand what the focus of modeling needs to be, and what architectural changes need to be considered	A matrix representation of the multi-sidedness of demand from the perspective of individual suppliers (complementors) within the ecosystem
Four quadrants	An analysis of the particular interest a modeler has in the behavior of an ecosystem with respect to what needs modeling, based on the modeler's assumptions concerning the three aspects bounding the analysis	Used whenever a model is to be constructed to define what aspects of the ecosystem are relevant to the modeler's interest	A visual representation of the resultant four different types of interest in suppliers' behaviors relevant to the modeler's interest

Effects Ladder analysis

An Effects Ladder is a way of describing the sources of indirect demand emerging from the context-of-use of indirect customers, organized in terms of the way they value outcomes.

In the example below, the orthotics clinic is supplying orthoses to the needs of patients within a local population, and orthotics clinic wants to understand the indirect demands that could emerge from wanting to improve the quality of care for that local population. This is a particular instance of a policy objective making indirect demands on the way orthoses are used, but also direct demands on the ways orthoses is supplied.

The overall needs of the local population are represented in Figure 55 as being above the '*know-how ceiling*' (K-ceiling) of the clinics providing services, with a number of drivers shaping the characteristics of that overall need. The effects ladder describes how this overall problem is transformed into a number of smaller tractable problems below the K-ceiling. Indirect value for the local population is therefore defined by the way these smaller tractable problems build towards addressing the overall problem. (Different patients may follow different patient pathways down the effects ladder.)

Outcomes provide solutions to these problems, represented in the example below as the thick numbered arrows. The '*context level*' (c-level) is used to represent the level below which an outcome can be provided with no knowledge of the indirect customer's particular situation, defining the indirect customer's context-of-use. Any outcome that solves a problem above c-level requires some degree of understanding of the particular indirect customer's context-of-use, since these problems represent indirect customer situations defining aspects of the patient's need. Thus outcome '1' is responding to a demand from a patient on a GP, to which the response is a consultation. Part of the value provided by the GP will be created by the way sub-problems are responded to, for example by physiotherapists ('2') or orthotists ('3'), ultimately leading to the in-house manufacture of bespoke manufacture ('5') or stock purchase ('6') of orthoses. The direct demands for '5' and '6' are how the orthosis supplier defines its market.

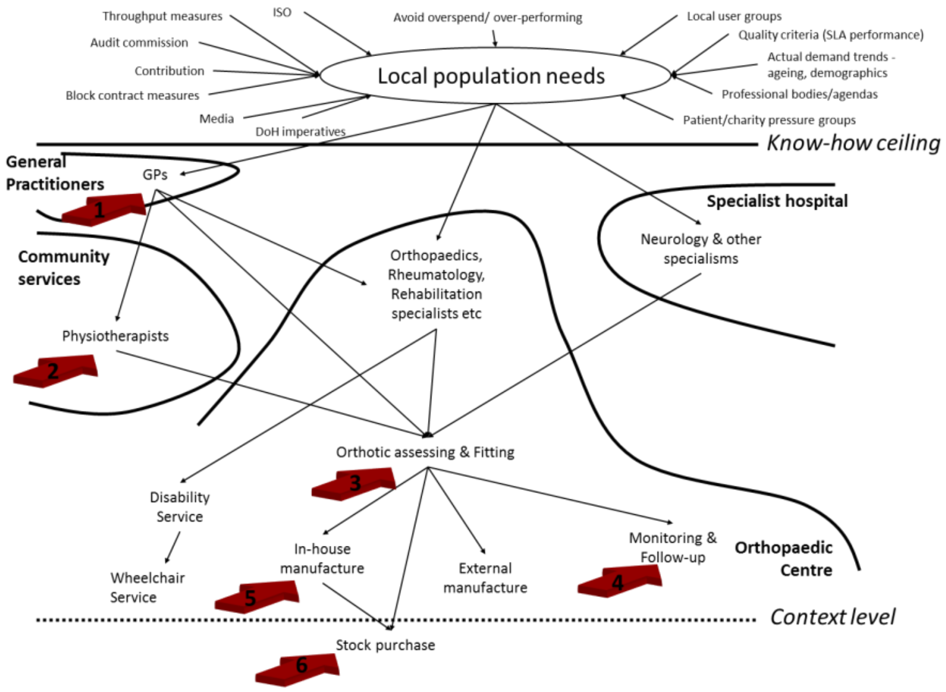

Figure 55: An example of an Effects Ladder

In this example effects ladder, GPs ('1') and Community Services ('2') are providing outcomes as well the orthopedic center, which is providing orthoses ('3', '5' & '6'), in turn using an orthotics service supplier, and monitoring and follow-up. From the perspective of the patient, their <u>value deficit</u> is the gap between their underlying need and the value of the outcomes provided. In this case, the patient's value deficit could be reduced by changing the way monitoring and follow-up ('4') was integrated with the other parts of the ladder. Doing this would require the orthotics clinics to go into the business of managing patient's chronic conditions on a through-life basis. Making this possible was the challenge facing the orthotics case [4]. To do so meant enabling the orthotics suppliers to support this indirect value in ways that were economically in their interests as well as in the interests of the UK government.

Effects ladder analyses are used therefore to establish how indirect customers organize the creation of indirect value in creating indirect demands. Effects ladders identify how the value deficits of indirect customers are organized, and the variety of outcomes through which suppliers can relate to this organization of indirect value. These effects ladders represent the ultimate contexts of use in which indirect demands are arising that are of interest to the modeler of the ecosystem.

Analyzing the multi-sidedness of demand

An effects ladder can be used to describe a wide range of demand contexts, for example the relationships between the decisive moments in a military campaign, or the key components to the way a direct customer creates value for its customers, or the relationships between the elements of a patient's overall condition. Understanding the multi-sidedness of demand involves understanding the ways in which these different decisive moments, key components or condition elements create direct demands within the ecosystem.

Within a military context, mission threads are used to provide a means of scoping and bounding the requirements associated with synchronizing events in response to a particular threat (for example in surface warfare [189]). Mission threads represent scenarios in which a system of systems is expected to perform in particular ways, and are described in terms of an end-to-end chronology of events with respect to which the interactions between numbers of systems can be described, expressed in terms of interactions between 'swim-lanes'. Within a healthcare context, the equivalent is the care pathway focusing on some aspect of a patient's overall journey in treatment of their particular condition, used to better align overall medical treatments to patients' conditions [98], and to better manage the alignment of hospital resources to securing particular patient outcomes [190]. Such mission threads can be used not only for requirements analysis [189], but also as a means of identifying quality attributes for use in an architecture evaluation of systems of systems [191], and at another level for end-to-end testing of services in service-oriented environments [192].

In understanding the multi-sidedness of demand, we make a key further distinction concerning the events within a thread or pathway: which events are 'external', associated with how an outcome interacts directly with an indirect demand in the effects ladder, and which events are internal to the way the outcome is itself organized. For example, in a vignette in which two ships are assigned to air defence [193], the external event constituting an indirect demand (in this case appearing as a threat) is the external air-launch of enemy missiles. The outcome organized in response requires that the two ships synchronize four internal events: detecting missiles being launched, assigning UASs to track the missiles, tracking using UAS sensors, and assigning missile engagements. Each of these internal events themselves involve a number of internal processes that have to be brought together and synchronized by the mission commander responsible for the outcome. In a medical situation, the indirect demand is the appearance of an external event in the form of a particular symptom, and the outcome needed to treat the particular condition involves the responsible doctor bringing together a number of individual treatments and synchronizing them to maximum effect on the patient's condition. The analysis starts from a particular variety of indirect demands in an effects ladder, each one corresponding to an external event. An internal composite process is then defined for each event, whether internal or external, in terms of a common set of underlying products or services. These underlying products and services used are the direct outputs of complementors defined as being operationally and managerially independent.

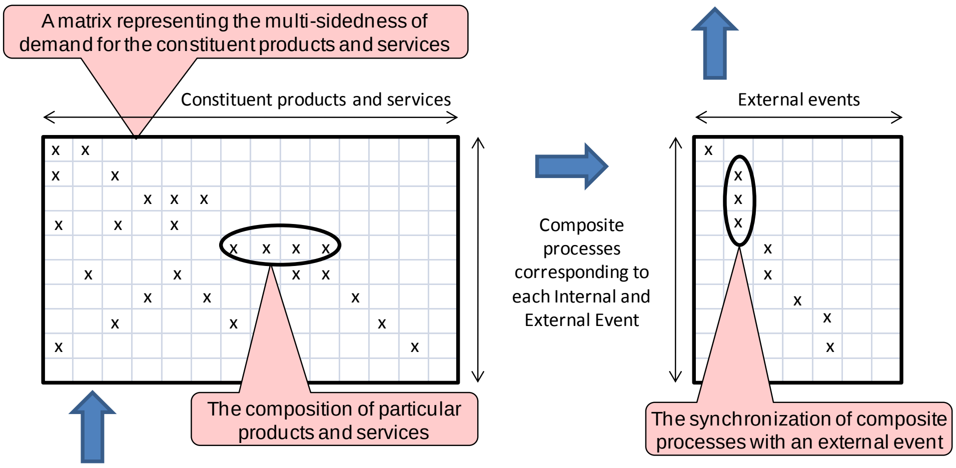

Figure 56: Defining the multi-sidedness of demand

The resulting left-hand matrix in Figure 56 defines the multi-sidedness of demand on any given product or service. Taken as a whole, it represents the architectural challenge facing suppliers within the ecosystem, depending on the way they define the variety of demands [135]. This architectural challenge involves managing the trade-off between purpose-building systems-of-systems for particular demands (i.e. directed or acknowledged systems of systems, described in the section discussing sovereignty on p24), or designing a multi-sided platform that has some measure of open-endedness in the forms of composite collaborations it can support, based on the variety of compositions that it can support that can then themselves be synchronized with respect to complete mission threads (i.e. the infrastructure supporting collaborative or virtual systems of systems, also described on p24).

Deciding what needs to be modeled

The effects ladders represent the ultimate contexts of use in which in demands are arising that are of interest to the modeler(s) of the ecosystem. Analyzing the multi-sidedness of these demands then identifies the forms of collaboration of interest to the modeler(s) between component systems needed to support those demands. The four quadrants analysis shown in Figure 57 brings these together with the three aspects of the ecosystem bounding the modeler's interest in the behavior of the ecosystem:

(i) The *domain of interactions* in which the analysis should be conducted. In the case of orthotics, this is the domain of interactions between orthotics suppliers, clinicians and patients.

(ii) The *relationships between supply and demand* within the domain, attending not only to the means of production, but also to the nature of the outcomes satisfying the contexts-of-use within which indirect demands arise. Of interest in this case are both the performance characteristics of the suppliers, and their relationships to patients within widely varying contexts-of-use defined by their developing conditions within the context of their lives.

(iii) How stakeholders impose *models* on the way supply and demand are aligned to each other through the agency of economic entities [97].

The way in which the modeler approaches an ecosystem in terms of these three distinctions defines four quadrants (described on p28).

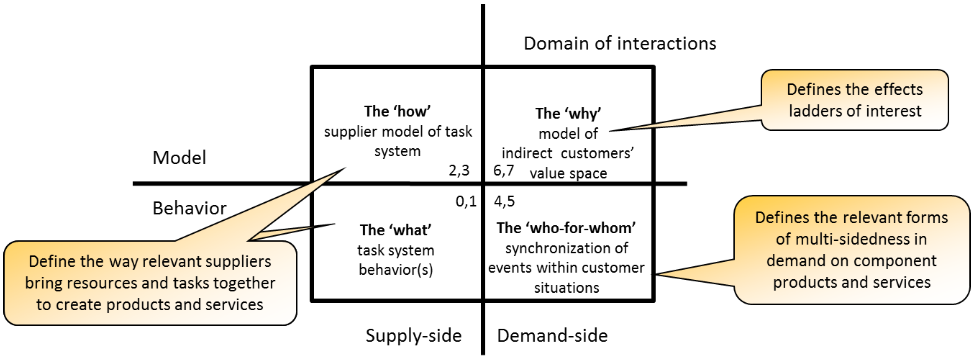

Figure 57: The Four Quadrants

In the orthotics case, the modeler's interest was in how changes could be made to the way clinics were run to reduce the value deficits experienced by patients that were also in the interests of the suppliers, involving the provision of through-life management of patients' conditions. The four quadrant analysis describes what needs to be included in an analysis of the ecosystem to meet such an interest, as exemplified in Figure 58:

Figure 58: An Instantiated Four Quadrant analysis

The three distinctions provide insight into the different asymmetries across which analysis is needed, and the particular level of detail within each quadrant. The analysis of the detail within each quadrant will identify the relevant stakeholders, the major types of relationship between them needing to be modeled, and the major types of economic entity through which each realizes its interests.

Modeling architectures

An ecosystem is a community of managerially and operationally independent organizations interacting with each other and with their environment. Thus the rows describing the multi-sidedness of demand describe particular relations of co-production between complementor organizations within an ecosystem defined by the columns of the matrix. This involves an enabling organizational architecture [162] as much as it does multi-sided platforms [182]. In order to describe alternative architectures within this environment, we need to describe patterns across the full range of domains. The stratification analysis of these patterns needs to describe both the is-a-part-of relations within particular products or services, and also the is-used-by relations between products and services [194]. And this analysis needs to extend across both the physical and the digital domains as more and more of products and services come to depend on software.

Stratification analysis

A preliminary version of this analysis can be derived from the four quadrants analysis. This starts with the capabilities in the bottom left and indirect demands in the top right quadrants in Figure 58, but splitting each quadrant into component and alignment layers, making eight layers in total. The economic entities spanning these different layers can then be identified, together with the processes of alignment that they use, further clarifying the stakeholders, task systems and relationships within and between the layers needing to be modeled, paying particular attention to the way the purchaser-provider boundaries are established between layers. This analysis aims to make the architecture of the relationships between supply and demand explicit as processes of alignment within and between the strata. Alternative architectures can then be represented as alternative ways of organizing this stratification, reflecting potential changes in the economics of the ecosystem itself that need modeling. An example of a preliminary stratification for the orthotics case is shown in Table 19:

Table 19: Stratification layers

Layer	0	1	2	3	4	5	6	7
4-quadrant layers	'what'		'how'		'who-for-whom'		'why'	
		Supply-side				Demand-side		
Organizations spanning layers			Healthcare services		General Practitioners			
		Orthosis suppliers		Healthcare Clinics			Patients	
Stratification layers	Orthosis suppliers	Orthosis supply *(align)*	Bespoke orthoses	Fitting orthoses *(align)*	Care episodes	Diagnosis and timing of care episodes *(align)*	Symptoms of the patient's condition	Condition drivers *(align)*

- Individual orthosis suppliers (layer 0) provide particular products (layer 1) that may be bespoke (layer 2).
- An orthotic service may be provided as a measuring (layer 2) and fitting service (layer 3).
- An orthotics clinic (layer 3) may order bespoke orthoses for fitting (layer 3) and adjustment within the context of other treatments (layer 4) within an episode of care referred by another clinician (layer 5).
- A general practitioner may be managing the episodes of care (layer 4) within the context of diagnosis and timing of care (layer 5) aligned to meeting their patients' needs.
- Patients may also determine their own need for treatments (layer 5) in response to their experience of their symptoms (layer 6), driven by the nature of their underlying condition(s) (layer 7).

In the orthotics case, the dominant relationship was between layers 3 and 4, with clinics providing episodes of care. To provide outcomes on a through-life basis, this relationship had to move up to being between layers 4 and 5 or between layers 5 and 6, depending on the complexity of the patient's condition. The clinic was then understood as the means of doing this economically within a primary care context, both in terms of managing more complex patterns of condition, and also in enabling more complex patterns of treatment. Describing the nature of this change in relationships within the ecosystem further defines what needs modeling. (In the AWACS case, this involved changing the role of the capability from being a flying radar to providing a forward mission command capability. In the UAS case, this involved changing the role of the UAS from being an eye-in-the-sky to being a critical node in a tactical mission capability.)

Appendix C – Value propositions shaping the way indirect value is created

Introduction

The supply-side layers 0-3 of a stratification, based on the primitive relations in 'Implementing Projective Analysis' (p47) describe the way a number of sovereign suppliers generate contracted-for outcomes. On the supply-side, the primitive relations define an underlying architecture of behavior for a supplier, the outcomes it generates being built up into activity chains.

The demand-side layers, however, describe the way these contracted-for outcomes are aligned to the particular demands of indirect customer situations. The different ways in which this is possible define the demand-side layering of the stratification (layers 4-7), and define value propositions. This appendix describes the way both activity chains and value propositions are derived from the primitive relations.

Activity chains and the architecture of suppliers' behaviors

An activity chain is a complex relationship, an example of which is shown in Figure 59 taken from the orthotics case. This defines a chain of events and processes leading to outcomes, including 'reverse flows' of information. These chains define layer 2 of the stratification, the chained events and outcomes being the outputs from layer 1. The capabilities and know-how determining the behavior of the processes generating these outputs define the content of layer 0, the processes themselves being in layer 1.

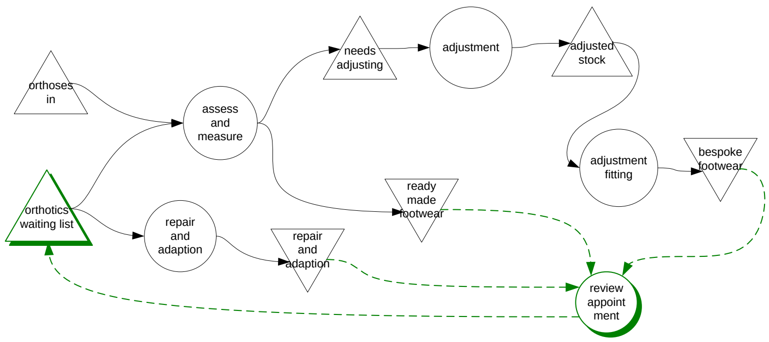

Figure 59: An activity chain

The behaviors of the chains of event, process and outcome, including the circular dependencies creating feedback loops (for example at the bottom of Figure 59) are themselves determined by the capabilities and know-how shown in Figure 60. These are the architectures of behavior that are directly accountable to an accountability unit forming part of the sentient system for a supplier organization. Referring to Figure 32, the control relationship of the unit is shown in sub-matrix 1b of the stratification. Sub-matrix 2b shows the 'reach-back' to units involved in a particular activity chain, and the superordinate units in the supplier hierarchy are in the 'hierarchies' sub-matrix.

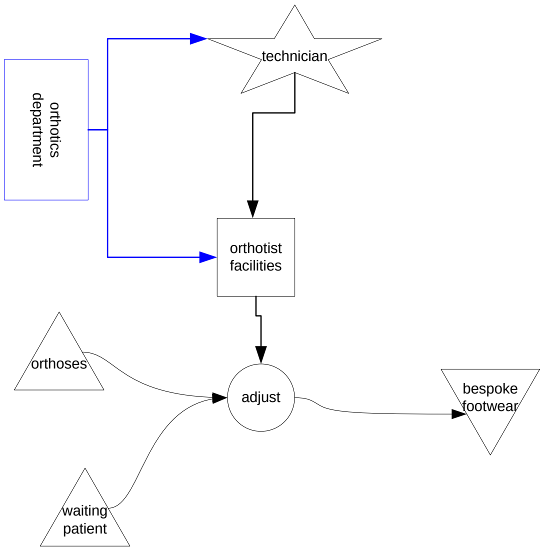

Figure 60: The architecture of behaviors

Patterns of structural alignment

Projective analysis models a world composed of suppliers and customers. Economic entities can be both customers (they use products and services) and suppliers (they provide products and services). One of the key perspectives of projective analysis is to take the view of the suppliers and consider how products and services are aligned in an appropriate and timely manner to both direct and indirect customer. Both timeliness and appropriateness depend on the agility of suppliers and customers in controlling the structural alignment of products and services to the indirect customer's context-of-use. It is this capability for structural alignment that is analyzed by the demand-side of the stratification.

There are four types of structural alignment, each one representing a different type of value proposition corresponding to a different relationship between layers in the stratification as follows:

- **r-type proposition**. An r-type proposition defines the *replication* of an outcome from layer 2 into layer 3. It therefore represents a fixed product or service that is generated in a way that is independent of even the direct customer's context-of-use. This is the traditional output for a sovereign business selling to its chosen markets.
- **c-type proposition**. A c-type proposition *customizes* an r-type product or service to a particular direct customer's context-of-use. The supplier can react quickly to a new requirement if it has capabilities that have been parameterized in such a way that pre-defined know-how can customize the way the capabilities can generate outcomes that satisfy new requirements.
- **K-type**. A K-type proposition is based on *know-how* about how to orchestrate multiple customized outcomes, orchestrating c-type propositions in relation to an indirect demand situation. This orchestration is under the control of a sentient system.
- **P-type**. A P-type proposition shapes a *problem* into indirect demand situations in a way that enables them to be satisfied by know-how propositions. This involves both anticipating the nature of the indirect customer's problem and shaping the nature of

the K-type propositions that, when synchronized, will satisfy the indirect demand situations.

The difference between these propositions lies in the patterns of primitive relationship modeled. It is the analysis of these complex relationships within a visual model of primitive relationships that define the relationships between the layers 3-6.

r-type proposition

The r-type value proposition represents the situation where the supplier provides the direct customer with a product or service that is defined independently of the direct customer's situation, for example in the supply of ready-made orthoses, making it dyadic in form. The orthotist can choose the orthosis best suited to the patient, but has no say in the construction of the product or service itself.

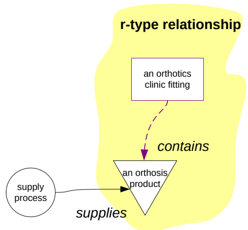

Figure 61: a replication (r-type) proposition

Three elements are involved in this type of proposition – a customer situation, an outcome, and a process that supplies that outcome. There is no information flow from any element on the demand-side back to the process or elements that influence the process.

c-type proposition

In the c-type proposition, the supplier can customize the behavior of the process by which the outcome is constructed for the particular direct customer situation, within the limits of the way the capability determining the behavior of the process has been parameterized. This makes this relation triadic in form. For example, the orthotics supplier can change the characteristics of the orthosis depending on the orthotist's particular order. This requires that there be a direct linkage between the direct customer's situation and the manufacturing know-how determining how the outcome is constructed. The manufacturing know-how and capability are determining the way the process generates the outcome for the customer situation, within constraints imposed by management. The direct linkage is indicated by the two green connectors going into the customer situation.

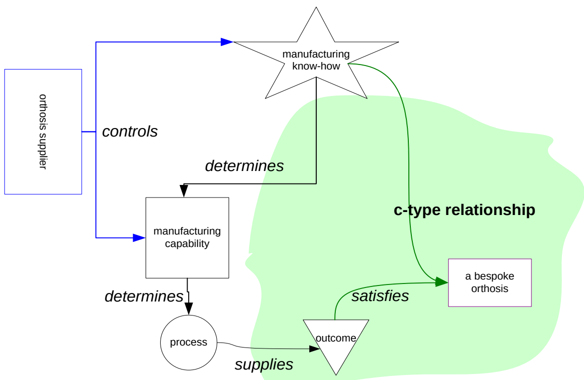

Figure 62: customization (c-type) proposition from an Orthosis supplier

K-type Proposition

The K-type proposition differs from the c-type proposition in that the know-how orchestrating the customized products or services is itself aligned to the indirect customer situation. In the c-type proposition, the way an outcome is customized is dependent on pre-defined feedback mechanisms. In the K-type proposition the manner in which the outcome is customized is dynamically determined by the supplier based on interaction with the indirect customer situation. This is modeled by an orchestration of the way customized outcomes are aligned to the customer situation. The supplier manages what kind of customization is possible in a dynamic way determined by the nature of the customer situation itself. For example, the orthotist in the clinic might manage the way a number of treatments are combined within a treatment episode. This involves selecting the orchestration that creates the best possible alignment between the customer situation and the available forms of customization.

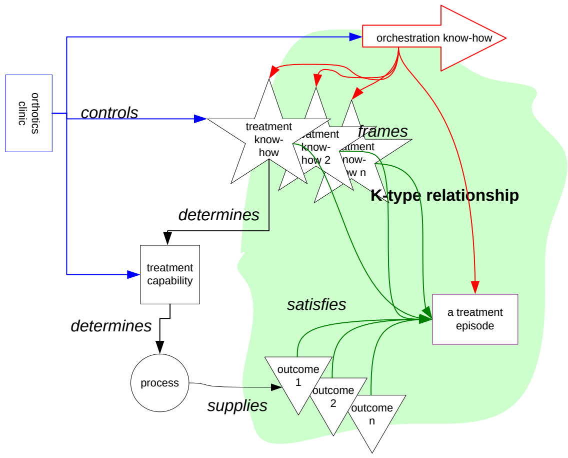

Figure 63: know-how (K-type) proposition

P-type proposition

The P-type proposition describes the relationship to a problem situation in which there is direct knowledge of what is problematic for the indirect customer. K-type propositions are tactical in that they are the means of satisfying customer situations that have already been defined. P-type propositions refer more to strategic concerns in which the nature of the customer situations are themselves emergent from the P-type process. An example might be a consultation with the patient about the likely prognosis (through-life characteristics) for their condition, and the development of indirect customer situations for the patient defining a through-life treatment strategy that maximizes the patient's quality of life, and which implies the design and construction of K-type propositions specifically for that patient.

In the P-type proposition shown below, the synchronization is under the control of an orthotics clinic that has a direct relationship to the patient's problem domain. The patient's domain is itself defined by both the orthotist and patient stakeholders, in which it is assumed that the orthotist will act in the patient's interests. This leaves open the question of how conflicting interests are reconciled in the definition of customer situations. Projective analysis identifies that there is a need for this, but the reconciliation would depend on a reflective analysis of the different stakeholders' interests.

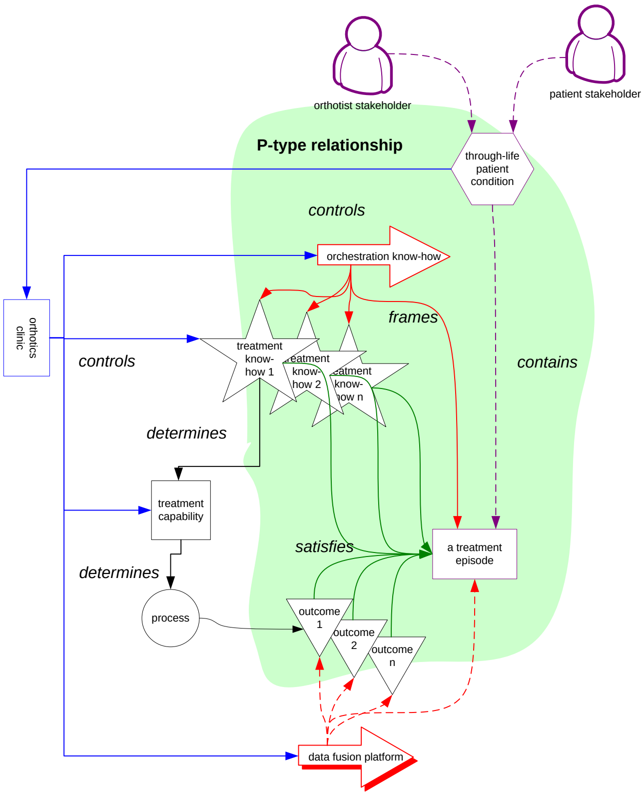

Figure 64: problem (P-type) proposition

Summary

These different types of propositions describe possible relations between suppliers and customers. They can all co-exist simultaneously within different parts of an ecosystem, generally with different stakeholders.

Appendix D – The relationship of Conceptual or Structural modeling to other types of modeling approach

Ecosystems contain large numbers of operationally and managerially independent organizations interacting with each other in supplying and purchasing roles. These ecosystems present challenges summarized as follows:

- The causal models governing each supplier's and customer's behavior cannot be assumed to be stable over time;
- As the numbers of the supply-demand relationships within the ecosystem increase, the indirect demands on a supplier due to the demand situations facing its indirect customers become increasingly important in shaping the supplier's choices.
- A supplier's ability to re-align existing capabilities to meet new indirect demands may be as important as the ability to develop and deploy new capabilities for meeting direct demands.
- Resolving the dependencies between such re-alignment and acquisition or development will in turn depend on how the supplier understands its place within the larger ecosystem.

These challenges limit the kind of modeling approach that can be used for describing and analyzing a supplier's relationships within such an ecosystem.

What is meant by 'modeling'

A model is a formal system of inference that stands in relation to an observed system-of-interest such that the inferential relations in the model commute with the observed relations in the system-of-interest. If these inferential relations can be simulated such that the simulated behaviors correspond to the observed behaviors of the observed system, then the system of inference can be said to describe the mechanism governing the observed system's behavior, and the observed system can be said to be simulable [195] (see section on First-order behavioral closure, p26).

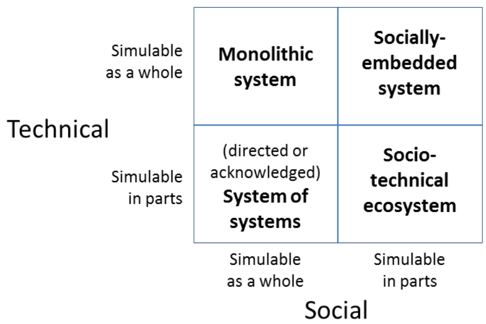

Figure 65: Modeling the mechanisms within a socio-technical systems-of-interest

Modeling the mechanisms governing the behavior of task systems within a supplier present familiar challenges to the engineer, whether as a single system [142], or as a system of systems [193]. But in these cases, there is a presumption of a sovereign enterprise determining the way the task system is to be used, whether directly under the control of the supplier, or subject to a contractual framework spanning multiple suppliers. New challenges emerge when this assumption no longer holds because of some surrendering of sovereignty by suppliers to customers, rendering the mechanisms governing the behavior of their sentient systems necessarily non-deterministic. This distinguishes the particular modeling challenges presented by socio-technical ecosystems, requiring that both the chronos axis of succession and the kairos axis of timespan of discretion be modeled.

Difficulties in modeling socio-technical ecosystems

Two difficulties present themselves when modeling socio-technical ecosystems. The first of these relate to the suppliers and customers within them being open systems that can be open at three levels. Systems that are open in this way are anticipatory systems [129], having the ability to be self-organizing through the way they anticipate the effects of their behavior on their indirect customers [130]. This makes it necessary to describe such systems in terms of their three levels of behavioral closure because of the third level being open to indirect customers' value spaces.

This brings us to the difficulty in determining what aspects of the behavior within and between suppliers and customers is ordered, meaning that behavior can be described in terms of mechanisms. For the behavior of a supplier or customer to be ordered, it must be possible to observe causal relations in its observed behavior that commute with the inferential relations in the model of its behavior. Given their levels of openness, much of the behavior of a supplier or customer cannot be described in this way, and is observed to be unordered in the sense that there are no immediately apparent relationships between cause and effect [186].

Thus while there may be behaviors within an ecosystem that are ordered and simulable, its characteristics as a whole cannot be assumed to be. Before imposing order on parts of an ecosystem through design, the modeler therefore needs to be able to understand the context within which such mechanisms are to be placed.

Distinguishing projective analysis from other modeling approaches

In constructing a model, there is a tradeoff between the model's level of disaggregated detail, needed to capture rich causal dependencies endogenously within the model, and the breadth of the model boundary [196]. Thus as the number of suppliers and/or customers within a model grows, so its emergent behaviors will increase, making it more difficult to relate the behavior of the model to its observed behavior [184]. Such difficulties cannot be avoided in modeling ecosystems because of their scale. The difficulties of modeling the organized complexity of these systems can be contrasted with other kinds of modeling as follows:

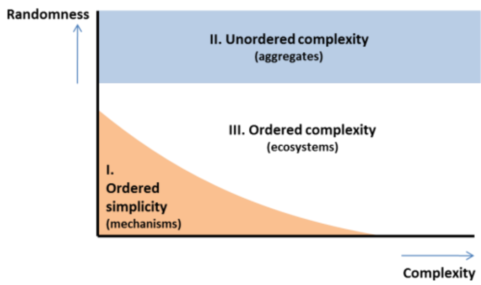

Figure 66: Contrasting different types of modeling approach (adapted from [197])

Thus mechanisms may be considered deterministic, so that calculus and differential equations become applicable (ordered simplicity in Figure 66), while statistical methods become necessary for dealing with the aggregates (unordered complexity in Figure 66). But in between we have the complex non-deterministic behaviors associated with the interactions between large numbers of operationally and managerially independent entities (ordered complexity in Figure 66 [197]). Ecosystems fall within this last space, even though individual systems within them may be modeled as mechanisms. The various modeling approaches associated with modeling these simulable systems can therefore be placed within their larger context as follows [198]:

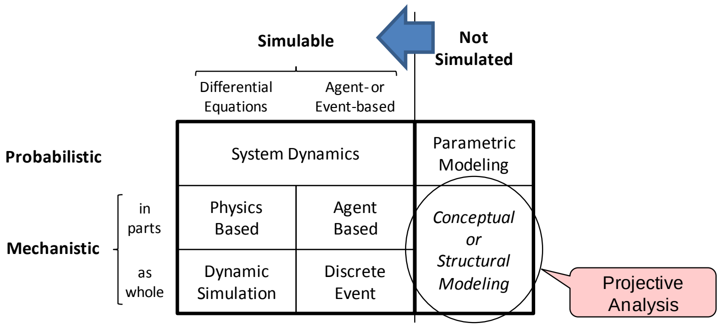

Figure 67: Comparing different modeling approaches (adapted from [198])

Given that the larger context of a supplier cannot be assumed to be ordered and simulable as a whole, we therefore have to start with the supplier in considering how these modeling approaches relate to ecosystems.

The supplier or customer starts by formulating hypotheses about cause-and-effect relationships, whether made about the ecosystem as a whole or in parts, the events of which can be represented along the chronos axis of succession. These hypotheses can then be tested using simulation methods, but the initial process of formulating these hypotheses starts with the supplier's or customer's perceptions of the structure-determining choices that can be made along kairos axes of discretion. This process is referred to as a process of projective analysis in which the modeler makes these hypotheses explicit by projecting them into the model. The process uses conceptual or structural modeling to represent the modeler's hypotheses [148]. Once represented, the modeler can then test the hypotheses in whole or in part through the use of simulation (represented in Figure 67 by the blue arrow), or use them as a basis for designing and developing new business architectures.

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