**Knowledge based (resource and capability) ontology for virtual enterprises**

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**Abstract:** Enterprise capability to manage change became one of the key success factors in a highly dynamic and turbulent business environment. Networks and Virtual Enterprises are one of the recent organisational concepts that are attracting increasing attention of the research and business community. The concepts outlined in this article help organisations in managing change and improving their operational flexibility and give enterprises an opportunity to create a globally competitive and highly complex operational competence by allowing network partners to focus on their core competencies.

The article proposes generalised and formalised definitions (and ontology) of key capability-related notions. The developed model integrates two complementary and related strategic management frameworks: the Resource-Based View and the Dynamic Capabilities Approach. The article also discusses the dynamic phenomenon of the development and reconfiguration of capabilities to emphasise the capability perspective of the organisational concept in question.

Finally, the article proposes a virtual enterprise resource and capability ontology as a useful specialisation of the resource and capability ontology. The article also shows its relation to the structural and behavioural characteristics of networks and virtual enterprises.

**Keywords:** resource; capability; competence; Resource-Based View (RBV); dynamic capabilities; network; virtual enterprise; ontology.

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1 **Introduction**

In the contemporary business environment, the unpredictability and dynamics of the environment are often experienced by enterprises as turbulence (Warnecke, 1993). This means that the enterprise is not prepared to handle the change in the environment using its existing business processes. Continuous change demands responsiveness and flexibility, efficiency and effectiveness in the organisation and in the execution of business processes. The result is that organisations are forced to do the following:

- restructure and develop higher level integration of business processes and adopt new organisational structures
- redesign traditional value chains and supplier-buyer relationships
- implement new management concepts and paradigms
- recombine and redesign the enterprise’s operational capabilities, etc.

All these must be done by trying to reuse and redeploy existing organisational knowledge.

Organisations handle the challenge of change in different ways. Winter (2003) identifies two major mechanisms for change:
ad hoc problem solving
2 adoption or development and application of high-level ‘patterned’ organisation
routines (also called Dynamic Capabilities).

Networks and Virtual Enterprises (VEs) are an example of highly dynamic organisational
structures. They are characterised by their flexibility and dynamic nature through
constant development and routine restructuring of operational capabilities. These
structures are characterised by their ability to set up business opportunity driven
capabilities on demand, where every particular order or business opportunity demands
(triggers) the structuring and the development of a unique set and configuration of
resources and capabilities.

The VE, as a goal-oriented and project-focused organisation, is a relatively new
concept of cooperation among enterprises, which takes advantage of a network
organisation that is the ‘breeding environment’ (Camarinha-Matos and Afsarmanesh,
2003) of such VEs. The use of the VE paradigm facilitates the management of change
and provides operational flexibility. This is because it is based on the combination and
recombination of relatively stable (organisational-, resource- and process-) building
blocks from multiple enterprises. The concept offers network partners an opportunity to
create globally competitive and highly complex operational competencies while allowing
each member of the network to focus on its core competencies.

In the literature, the concept of networks and VEs (in terms of structural and
behavioural characteristics and features) (Tølle et al., 2002), as well as resources and
capabilities on a company level (Eisenhardt et al., 2000) have been well discussed and
defined. However, the authors have experienced a lack of explicit and well defined
concepts and terminology concerning the capabilities and resources when applied in a VE
and network environment. Since capabilities and resources are fundamental concepts in
modern strategic management, it is expected (or at least hoped for) that these concepts
could help explain the dynamic nature of the organisational concepts in question. For
example, these concepts can shed light on how to develop and reconfigure capabilities on
the network and VE level. The question is nontrivial because the authorities, ownership
and management processes (including strategy making) are quite different on the network
and VE levels from those at the individual company level.

In Section 2, the article proposes generalised definitions of the key notions (e.g.,
business processes, resources, capabilities and competencies) considering the basic tenets
of the Resource-Based View (RBV) and of the Dynamic Capabilities Approach (DCA)
(Helfat et al., 2003; Eisenhardt et al., 2000; Teece et al., 1997; Winter, 2003). Section 2
also discusses the nature of capability development and its reconfiguration. It also
presents different possible pathways for the associated organisational change. Finally, it
discusses the hierarchy of capabilities.

Section 3 continues with a brief definition of the VE concept, whereas Section 4
presents a mapping of structural and behavioural characteristics of VEs onto the
generalised resource and capability ontology.
2 Resource and capability ontology

2.1 Business process

The *Oxford English Dictionary* (Oxford University Press, 1999) defines *process* as a series of actions or operations conducted to an end or as a set of gradual changes that lead toward a particular result.

According to Davenport (1993) and the ISO9000: 2000 family of standards (2000), a *business process* is a structured and measured, managed and controlled set of interrelated and interacting activities that uses resources (e.g., different tangible and intangible assets, people and other external resources) to transform inputs into specified outputs. Davenport also proposes a *differentia specifica* of business processes: every process relevant to the creation of an added value is a business process.

Business process outputs can be categorised as follows (see Figure 1):

1. *inputs* to subsequent processes (the output of business processes BP₁ is the input of business process BP₃)

2. *resources* for subsequent processes (the output of business processes BP₂ is a resource necessary to carry out business process BP₃, such as the development of a new technology or specific assembly device is a resource for a manufacturing process)

3. *final products* delivered to the market (such as goods or services).

**Figure 1** A simple model of a business process (consisting of business processes BP₁, BP₂, and BP₃)
2.2 Resource

A resource is an entity that is able to perform a certain class of operations involved in the transformation of inputs (material and/or information) into output(s). Resources are assigned to activities (or processes) according to their adequacy (capability and ability) to carry out operations or activities to deliver the required outputs.

Strictly following the engineering consideration and terminology of resources (such as reflected in the IDEF0 modelling language (KBSI, 2001)), resources are the mechanisms that perform processes (see Figure 1). The engineering definition of resource is in contrast with definitions in management and economics (Investorwords.com, 2004). Regarding economics, resource includes all ‘transformation inputs’ (material, data and information, energy, cash, etc.). According to the engineering definition, however, resources are not transformed during activity/process execution.

According to the GERA Modelling Framework of GERAM (IFIP-IFAC Task Force on Architectures for Enterprise Integration, 2003) resources have two different forms of physical manifestation. Each of these can be human or non-human (automated):

- The software (SW) is a (partially controlled) state of hardware enabling it to perform certain operations. Examples for SW are procedures for employees, a configuration of manufacturing facilities, a computer program and a control algorithm. Thus, the software is an ‘abstract resource’. It can only exist in hardware. ‘Software makes hardware behave in a certain way’.

- The hardware (HW) resources are physical entities that have the capability to perform some sets of tasks (in certain contexts and states). HW can be described by its capabilities. For machines, this is the set of operations/activities it can perform under specified conditions. For humans, it is the set of physical and mental abilities.

For a resource to be considered as a candidate for the performance of a process (or activity), it must meet the performance requirements of the process/activity. Usually, resources must be aggregated and brought into a certain state to be able to perform a process/activity.

The division between HW and SW is related to (although is not equivalent to) the division of resources into tangible resources and intangible resources.

It is often useful to consider the company specificity of resources. Accordingly, they can be divided into nonspecific resources (or general purpose resources which could be acquired on the market, such as machines, computers, software products) and company-specific resources. Company-specific resources (as well as capabilities), which fulfil the criteria of being valuable, rare, inimitable and nonsubstitutable (VRIN resources), are a source of potential competitive advantage to the organisation. Therefore, the management of company-specific resources is strategically important for any company.

The resources necessary to perform an activity/process may be owned and/or leased (such as employees who have skills, knowledge and know how).
2.3 Capability

Capability is a firm’s ability to execute relevant, interacting and interrelated business processes, linked with the common mission to transform inputs into specified (requested, expected) outputs by the use of resources. Having a capability implies a permanent or temporary integration, configuration and clustering of resources, which are defined by the structural and behavioural characteristics of relevant business processes.

Therefore, the set of capabilities maintained by an enterprise has an integrative purpose insofar as it defines the overall behaviour of the organisation. This integrative purpose is a systemic property of capabilities. The integrative purpose (the ‘mission’) of the capability may be any of the following:

- **functional**, where the capability exists to perform a (sometimes complex) function\(^6\)
- **cross-functional**, where the capability is not restricted to a single function or a domain\(^7\) (e.g., a capability that delivers superior quality goods or services, a design capability that can deliver innovative product designs; in the presented context the capability may have qualifying properties).

Winter (2000) defines the organisation’s capability as a high-level routine (or a collection of routines), where routine is considered as a behaviour that is learned, highly patterned, repetitious, or quasi-repetitious, founded in part on tacit knowledge (Nelson and Winter, 1982). Dosi et al. (2000) argue that capability:

- represents organisational – collectively held – knowledge, which arises from the integration and coordination of specialised knowledge
- coordinates the performance of individual tasks.

Winter (2003) also defines capabilities as complex and structured, where capabilities are built hierarchically from ordinary, zero level, operational capabilities into higher order ones. We add to this characterisation the distinction between capabilities that have the purpose related to the organisation’s mission (to produce goods and deliver services) and dynamic capabilities that have the purpose to build capabilities.

A capability as an entity has its own evolution, characterised by typical stages in the capability’s life-history. Helfat et al. (2003) identify four major stages:

1. founding
2. development
3. maturity
4. possible branching into retirement, retrenchment, renewal, replication, redeployment and recombination.

Capability hierarchy and capability evolution will be discussed in more detail in Section 2.5.
2.3.1 Capability as a complex entity

Capability is an entity that can appear at different levels of complexity from low to high levels. A complex capability can be composed of elementary, lower level capabilities. Examples of elementary capabilities are the following: process and technology design, design of IT process control and quality-driven culture (such as having a shared processes of negotiation and coordination).

Simple (elementary) capabilities might be imitated, replicated or emulated through the acquisition (hiring) of resources. However, practice shows that with complex capabilities this is not the case. The common perception in industry is that the more complex a capability is, the less it is formalisable and able to be imitated, replicated or emulated. Also, even if a capability is not impossible, it is certainly unfeasible. All these features make complex capabilities not tradable.

Some reasons for this nontradability stem from the definition of complex capabilities. Although there may still be other reasons for this nontradability (which are not investigated in the context of this article). Complex capabilities arise from the combination of more elementary capabilities. This combination is based on:

- an integration of elementary functions into a more complex process, whereupon the complete process may not be explicitly known (or known in enough detail) by any single person in the company (often the process and the resulting capability is the result of an evolution)
- an agreement by organisational entities (individuals or higher level aggregates, like groups, departments and committees) to contribute according to the needs of this process.

If the process is known, but only informally, then it is difficult or impossible to transfer it by trading its descriptions. Even if individual elements of the process are available in an explicit, detailed and formal documentation, these elements might only be integrated through ad hoc means. If this is the case, then the transfer of integration knowledge causes difficulty. In case the organisation is not fully aware of the existence of such informal or tacit knowledge, the nature of the organisation’s complex capabilities remains hidden.

In some cases, a complex capability can be explicitly described. However, this description may be ridden with causal ambiguity (Lippman and Rumelt, 1982; Simonin, 1999). Therefore, only in limited cases can imitation and replication be collapsed into a simple problem of information transfer. The problem is that models of the capability may not capture all behaviours that are relevant to decision making regarding the capability or for the (re)learning of it. For example, some contextual elements that have been unchanged in the source environment (and causally influenced the success of the capability in question) may easily remain disregarded. In the lack of a clear understanding why a capability works in a given market and cultural context (including internal organisational culture), replication in practice is often impossible without transferring people (which may also minimise investment into the conversion of non-externalised knowledge into an externalised one). For this reason, if a company is able to emulate a capability, the created capability will actually be company specific.
2.3.2 Capability role in resource productivity

Studies of resource productivity have shown that two identical sets of machines, tools, etc. can have different productivities.

Different productive values seem to derive and depend on how these resources are structured, are linked and behave as a whole. In other words, productivity depends on the specific structure of the capability.

Elements that constitute a capability do not exist in isolation from each other. They only have meaning and value when linked. Out of the subsequent discussion, it will be concluded that the productivity of resources is a property of the complex capability.

Productivity, and therefore efficiency, also depend on whether the processes involved in the capability are internalised (i.e., whether the processes have become routine, tacit knowledge) or performed in an explicitly controlled manner.

In practice, we can find examples where companies accumulate a large stock of valuable technical resources and still do not have many useful capabilities.

2.3.3 Capability value

A capability’s value is hard to measure and quantify. The main reason for this seems to lie in the capability’s rather abstract nature (it is not a visible, physical and tangible asset) and dependency on the individual organisation (complex capabilities are company specific and endemic).

A capability’s value also changes over time when associated with the appearance of competition or possible substitutes. The appearance of competition (in terms of resource or capability substitutes, which are functionally similar to the original ones) or product substitutes can diminish the value of the capability. In a competitive environment, if a capability has no further extendibility, then the capability can become obsolete (e.g., the market has no longer a demand that can be satisfied using the capability in question).

Capability has a positive monetary value (also defined as an opportunity cost) if it provides a competitive advantage for the company.

To conclude, capability value changes over time periods and business contexts.

2.4 Core competence

Competence can be defined in its simple form as demonstrated capability. Core competence is a company-specific capability that distinguishes the company from its competitors. It also defines the essence of the company’s business.

The firm specific (core) competencies are a source of the firm’s competitive advantage. Therefore, according to Hamel and Prahalad (1994), a core competence must ‘pass’ a test based on the following criteria:

- **customer value** – a core competence must make a disproportionate contribution to customer-perceived value of the firm’s products or services
- **competitor differentiation** – the capability must be competitively unique
- **extendibility** – a core competence is not merely the ability to produce the current product configuration (however excellent that product line may be), but it must also be able used as a basis of potential new products.
There exists a tangible link between core competencies and core products. Core products and services are the embodiments of the application of one or more core competencies.

Regardless of how wide a company product portfolio may be, companies are, from the perspective of underlying core competencies, usually very focused and coherent. The Canon case study\textsuperscript{12} (Mintzberg \textit{et al.}, 1999) indicates that the portfolio of core competencies may be narrow – no matter what is the size of the company or the number of its end products.

Control over core competencies or core products is essential for the company because it allows the company to shape the evolution and different applications of its competencies through embodying them in a variety of end products.

### 2.5 Capability evolution: the dynamic capabilities approach

In the contemporary business environment, organisations are faced with the high dynamism of changes. Organisations have to survive (and hopefully strive) in the changing internal and external business environments. This kind of survival requires a combination of adaptivity, flexibility, innovation and organisational responsiveness.

Capabilities may need to change because of either external causes (imperatives of the business environment) or internal causes (sanctioned by management decisions). Due to the dynamism of the business environment, organisations face some key capability related questions (Barney, 1991; Nelson, 1991; Penrose, 1959; Peteraf, 1993; Teece \textit{et al.}, 1997; Wernerflet, 1984):

- What is the impact of external and internal changes on the company’s capabilities, and how should capabilities change as a result?
- How should the competitive advantage of the company be sustained in the changing business environment – use existing or build new capabilities?
- Which are ‘the environmental enablers’ of an organisation that allow capability development (or, why are certain enterprises capable of developing new capabilities or renewing existing ones, whereas others are not)?

Organisations have different possible ways to change. Winter (2003) identifies two major change mechanisms. The first mechanism is \textit{ad hoc} problem solving where actions appear as a response to novel challenges from the environment or from other unanticipated events. This approach does not constitute a routine. Therefore, it is not highly patterned or repetitious but is at least ‘intendedly rational’.

However, organisations may develop certain \textit{change management patterns} consisting of rules, actions (or a behaviour) and structural principles (Eisenhard and Martin, 2000), where the pattern may be learned and contribute positively to the effectiveness of future actions or changes. This pattern could be akin to a \textit{skill} or \textit{routine} and can grow into an organisational capability called the Dynamic Capability (DC). In other words, Dynamic Capability is the capability to create dynamically or change existing capabilities.

Teece \textit{et al.} (1997) define DC as the firm’s ability to integrate, build and reconfigure internal and external competencies. The ‘mission’ of Dynamic Capabilities is not the production of goods or the provision of marketable services but rather refers to the building, integration or reconfiguration of operational capabilities. Therefore, DCs do not directly affect the outputs of the company, but indirectly contribute to the firm’s output through their impact on operational capabilities.
No matter how much companies would like to be rational and skilled in a change initiative, practice shows that the complexity of real life many times overtakes the scope of DCs. Such real life situations require a complementary combination of ad hoc problem solving and DCs.

The successful maintenance of a skill or routine, relevant to a company’s change initiatives (or for development of dynamic capabilities themselves), typically requires frequent exercise. However, attempting too much change (perhaps in a deliberate effort to exercise DCs) can:

- impose additional cost because of frequent disruption of the underlying capabilities
- limit the ability to learn the lessons of any particular change (due to the bounded rationality of human beings).

There is an ecological demand for a balance between the cost of the (dynamic) capability and the use that is actually made of it (Teece et al., 1997).

DCs help us understand how idiosyncratic attributes of the individual firm affect its prospects in a particular competitive context. DCs are also manifested in the company’s (management) ability of sensemaking (retrospective) and interpretation of previous events (decision’s impact on the current business reality) and imagination (interpretation of future needs and conditions). DCs should be able to identify productive opportunities and should result in decisions about the development of new capabilities or the reconfiguration and renewal of existing ones.

The decision about where a firm can and should go, in terms of the future development of its capabilities or competencies, does not simply depend on some ‘rational’ process. This rational process identifies different opportunities and considers industry attractiveness (for instance, decisions made based on an analysis of Porter’s five competitive forces of industry attractiveness (Porter, 1980)).

A firm’s trajectory of competence development is path dependent (Teece et al., 1997). Path dependency means that the choice about domains of competence is influenced by the current position of the company’s competencies, past choices and future possibilities and conditions. Namely, firms make long-term, quasi-irreversible commitments to certain domains of competence. These commitments could easily transform an organisation’s core capability into its organisation’s core rigidities. Also, the path ahead in competence development should be influenced by industry foresight (understanding of technological, lifestyle, demographics, economics, regulatory changes and trends that will affect the industry or competency). Identifying competitive forces may help, but their interpretation is up to the individual company’s management.

### Capability hierarchy

From the discussion in Section 2.5, it follows that there is a recursive hierarchy between DCs and ordinary capabilities. Winter (2003) defines DCs as higher order capabilities that operate to extend, modify or create ordinary capabilities. DCs govern the rate of change of ordinary capabilities.

An example of a DC is the capability to develop new products that affect the product mix, the production processes and the way in which customers are related to the new products. New product development capability is a prototypical example of a first-order dynamic capability. The capability to create a new outlet (bringing together real estate,
design skills, construction, equipment, advertising campaign, hiring and training of new employees, setting up processes, etc.), where the company has centralised staff focused on the creation of a new outlet, is another typical example of DCs.

In contrast with DCs, ordinary, operational or ‘zero-level’ capabilities permit a firm to ‘make a living’ in the short term by producing and selling its products and collecting the revenue from customers.

The relationship between DC and operational capability, in terms of the role of DC in the founding, development or renewal of operational capabilities, opens another important question – how and why companies are able to create DC.

Similar to the aforementioned relationship, where a DC creates or reconfigures an operational capability, the authors believe that the company should nurture certain higher order capabilities, which make it possible to create (or improve) DCs. These higher order capabilities include the following:

- learning\(^{13}\) and knowledge management\(^{14}\)
- management\(^{15}\) and leadership\(^{16}\) capabilities.

2.6 **Capability as a knowledge category**

Capabilities are a form of knowledge that the organisation has. In the section below, capability will be characterised using different knowledge attributes and knowledge categories because this helps in understanding the difference between operational and dynamic capabilities. Figure 2 presents some basic knowledge categories (Kalpić et al., 2004):

- tacit versus explicit knowledge
  - **Explicit** knowledge is knowledge that can be articulated and written down; Therefore, such knowledge can be externalised and consequently shared and spread.
  - **Tacit** knowledge is developed and derives from the practical environment. It is highly pragmatic and specific to situations in which it has been developed. Tacit knowledge is subconscious. It may be understood, but when used it is not identified in a reflective or ‘aware’ way.

- internalised versus externalised knowledge
  - **Internalised** knowledge is limited and present in a person’s head.
  - **Externalised** knowledge has a form of external records (e.g., written text, drawings, models, presentations, demonstrations).

- formal versus not-formal knowledge
  - Insofar as an externalisation may have a formalised representation or not, ‘formalisation’ here means that the external representation of the knowledge is expressed in a consistent and complete mathematical/logical form (or equivalent).

- individual versus collective knowledge
  - **Individual** knowledge is limited to an individual and gives a person the ability to carry out certain tasks.
b Collective knowledge is shared by members of a group, where individuals contribute their personal knowledge to a cohesive and integrated whole (e.g., the knowledge how to develop a new product). Collective knowledge that the organisation has is more than the sum of the knowledge of individuals in the organisation (which makes the productive value of the knowledge of an individual higher when linked with the knowledge of other individuals).

- conceptual versus pragmatic knowledge
  a Conceptual knowledge is an abstract or generic knowledge generalised from particular instances.
  b Pragmatic knowledge is related to matters of fact or practical affairs (procedural or ‘how to do’ knowledge).

Figure 2 Knowledge categories

Capability as knowledge can be characterised by the knowledge attributes introduced above. Based on the discussed features of operational and dynamic capabilities, it seems that operational capabilities fit most naturally with the category of pragmatic knowledge, whereas dynamic capabilities fit the category of conceptual knowledge.

Dynamic capabilities are manifested in a top manager’s capability of sensemaking, imagination and interpretation. DCs are built on:

- fundamental and conceptual knowledge of the relevant domains
- pragmatic knowledge (usually applied in the form of different frameworks, methodologies, tools, etc.)
- cultural and situation-shared knowledge, which help in the explanation and understanding of the past and present organisation’s behaviours and decisions as well as anticipating future needs and (productive) opportunities.

In the present context, DCs are conceptual (abstract and generalised) knowledge about a domain in question.
Operational capability is the knowledge of how to do things. This knowledge could be procedural, prescriptive and deterministic (for detailed definition of associated knowledge attributes, see Table 1). These features make this knowledge explicit, which could be potentially externalised and formalised. However, we should not neglect the following facts:

- operational capability (and associated business processes) is more efficient if it is performed as a routine (capability is internalised and tacit)
- many operational capabilities are highly complex and their associated business and decisional processes are unstructured or ad hoc in nature.

This complexity makes capability difficult in its formalisation and imitation or replication, which makes the capability tacit.

<table>
<thead>
<tr>
<th>Tacit</th>
<th>X</th>
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<tbody>
<tr>
<td>Explicit</td>
<td>X</td>
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<tr>
<td>Internalised</td>
<td>X</td>
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<tr>
<td>Externalised</td>
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<td>Formal</td>
<td>X</td>
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<tr>
<td>Not-formal</td>
<td>X</td>
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<tr>
<td>Individual</td>
<td>X</td>
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<tr>
<td>Collective</td>
<td>X</td>
</tr>
<tr>
<td>Pragmatic</td>
<td>X</td>
</tr>
<tr>
<td>Conceptual</td>
<td>X</td>
</tr>
</tbody>
</table>

### 3 Enterprise networks and virtual enterprises

Contemporary enterprises cooperate with other enterprises in all phases of the product life cycle to demonstrate a worldwide competitiveness and highly complex competence. This cooperation can speed up the product development process, increase their operational flexibility, achieve cost reduction and allow them to focus on core competencies (Tolle, 2003). This preferred method of cooperation between partners is becoming a goal-oriented, project-focused cooperation usually done in VEs.

While from the customer’s point of view, a VE is functionally identical to a company, the VE may be in fact:

- a temporary association of companies to perform a one-of-a-kind task (e.g., building a bridge)
- an association of companies towards the purpose of performing some sustained task during a period of time.
To present the relationship between the network and the VE, an example of network and VE life histories will be presented in brief. This example starts with the identification, preparation and setting up of the network. At some point in time, during the operational phase of the network, a customer contacts the network with a request for quotation. The network sets up a quotation VE, which delivers a quotation to the customer who later accepts (or rejects) it. If the quotation was successful, the network sets up another VE, which will deliver the quoted product (by performing the detailed design of the product, builds it and releases it to operation). From this example, it can be seen that the enterprise network can be considered as some kind of ‘breeding ground’ for setting up VEs. When the customer’s requirements are satisfied, the experiences gained in the VE are transferred back to the network. The VE is then decommissioned, and the network waits or seeks other possibilities in the market.

Essential to the competitiveness of this business model are the speed and reliability with which the network can set up competent VEs. Fast VE setup could be jeopardised if the VE is composed of partners unknown to one another before the formation of the VE. As part of forming an enterprise network, partners need to establish, in a short time, a degree of preparedness to be able to configure world-class competencies (in order to meet customer demands), based on the capabilities available in the network.

When setting up an enterprise network, one of the key questions to consider is the level and type of preparation in the network and among the network partners. Reference Models (RMs) are important means in this preparation. RMs allow quick, low cost and secure VE creation. The purpose of the RMs is also to capitalise on previous knowledge by allowing model libraries to be developed and reused in a ‘plug-and-play’ manner, rather than developing models from scratch.

4 The resource and capability ontology model for VEs and enterprise networks

In this section, the article separately maps and discusses the structural and behavioural characteristics and features of networks and virtual enterprises through the perspective of resources and capabilities (see Table 2).

<table>
<thead>
<tr>
<th>Product (deliverable)</th>
<th>Network partner</th>
<th>Virtual enterprise</th>
</tr>
</thead>
<tbody>
<tr>
<td>VE with the mission to deliver the requested product to the customer</td>
<td>Service to the VE (using the partner’s core competence)</td>
<td>Goods or services on demand (requested by the customer)</td>
</tr>
<tr>
<td>Service to the VE (using the partner’s core competence)</td>
<td>Core competence useful for some potential VEs according to VE requirements</td>
<td>a. Capability to deliver requested product</td>
</tr>
<tr>
<td>Core capabilities (competencies)</td>
<td>Core competence useful for some potential VEs according to VE requirements</td>
<td>b. Capability to manage VE (known as a governance capability)</td>
</tr>
<tr>
<td>a. Creation of a new capability (or VE) – capability on demand</td>
<td>c. Network partner development capability</td>
<td></td>
</tr>
</tbody>
</table>
Table 2  The review of main resource and capability related features of networks and virtual enterprises (continued)

<table>
<thead>
<tr>
<th></th>
<th>Network</th>
<th>Network partner</th>
<th>Virtual enterprise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>a. Knowledge about partner capabilities</td>
<td>Resources made available/committed to be used in VEs</td>
<td>a. Committed by VE partners (with their capabilities) to the VE</td>
</tr>
<tr>
<td></td>
<td>b. Network reference models</td>
<td></td>
<td>b. Protect (VE) management reference models</td>
</tr>
<tr>
<td>Dynamic capabilities</td>
<td>a. Creation of a new capability by establishing VEs</td>
<td>Capability of network partners</td>
<td>In case the VE is a long-term operation, it may have its own dynamic capability to re-organise (e.g., in case of unacceptably long breakdown in the operation)</td>
</tr>
<tr>
<td></td>
<td>b. Capability to learn e.g., to improve VE creation processes</td>
<td>To learn and improve functional and alliance capabilities form participating in VEs (which allows them to become qualified partners to the network)</td>
<td></td>
</tr>
</tbody>
</table>

4.1 Enterprise network

The capability to create a new VE is a core competence of the network, which has the particular mission to deliver the requested product to the customer. This creation capability is a high-order capability. Also, it has the property of Dynamic Capabilities – the creation of VEs is really about the creation of a new capability called the capability on demand. The creation capability has an integrative purpose manifested in the integration and structuring of network resources and partner capabilities into a capability (VE competence), which can compete in the market.

The network management capability is another one of the network’s core capabilities with the mission to manage the following:

- network processes and resources such as carrying out marketing and sales tasks, analysing customer requirements, setting up VEs and performing network partner qualification

- network knowledge and associated knowledge processes: from capturing to formalisation of the knowledge (in the form of different RMs) or assessment of relevance and reusability of captured knowledge.

Network management also includes some typical management tasks such as the control of task execution, measurement of the network performance over Key Performance Indicators (KPIs), decision making and development (establishment) of the shared goal hierarchy among network partners (aligning of their mission, vision, strategies and objectives).
To participate in the network, a partner should possess functional and alliance capabilities (capability to integrate in the network) and should meet certain network requirements and standards. Consequently, the network has to be capable of defining these requirements and standards for the identification, selection and qualification of network partners or their capabilities. This identified core capability may be called network partner development capability.

Besides the operational capabilities of the network, some DCs can be also identified. The network’s capability to learn, in terms of experience collection and its mapping (as part of VE decommission processes) into (a) new reference models (RM) or (b) modified existing RM is a prototypical example of a high-order (Dynamic) capability. With the learning process specifically, the capability to create new capabilities (VEs) is improved and upgraded that also exemplifies a typical path-dependency process.

The network operates using different resources, where some of them are ‘firm’ (network) specific such as the knowledge about partner capabilities (what partners are capable of doing). This knowledge is a typical example of meta-knowledge.

Network reference models are another very important type of network resources. These could be used in a ‘plug-and-play’ manner in the process of VE creation. There are many different examples of RM, such as the following:

- business process models
- organisational and decisional models
- legal/contractual models
- IT infrastructure (e.g., access rights and standard interfaces)
- environmental and quality management (in the form of procedures and manuals)
- network KM models.

4.2 Virtual enterprise

VE is the ‘deliverable’ of network processes and activities. The VE’s mission (and core competence) is to deliver goods or services on demand as requested by the customer. A VE’s core competence is usually a cross-functional type of capability (focused on the performance of a set of particular functions such as the designing and building a product).

To be capable of delivering the requested products, a VE also has to demonstrate the capability to manage the VE. This includes the following:

- manage the VE’s processes and resources
- plan and schedule the VE’s activities and allocate resources accordingly
- control task execution of the VE
- any other decision-making task related to the VE’s operation.

Each of the above capability may also be called a governance capability.

DCs, in the case of VEs, are necessary for network partners to learn and improve their functional and alliance capabilities from their participation in VEs.
5 Conclusion

The article discusses ontology of capabilities and competencies and its application to Enterprise Networks and Virtual Enterprises. This ontology is built on the premise and theoretical framework of the Resource-Based View and the Dynamic Capabilities Model of management theory. The ontology defines company capabilities as integration and structuring of company-specific, company-nonspecific and external resources into a productive configuration. Capabilities of strategic importance are those that meet the criteria of:

- contributing a disproportional percentage of customer value
- contributing to competitor differentiation
- being extendible.

The application of capabilities to deliver end products is considered as the set of core competencies of the company.

Capabilities (competencies) compete on the market with competitors. The market is the only one that approves the competence’s competitive advantage, its productive opportunity and what is the competence’s true value.

The presented model also introduces and discusses the role of DCs in the dynamic phenomenon of capability creation. Dynamic Capabilities, being meta-capabilities, are those capabilities that create and develop new capabilities or renew and reconfigure existing ones. DCs are routinised responses to familiar types of organisational changes.

Considering a capability as a knowledge instance and following the knowledge categorisation of Section 2.6, this article identifies a correlation between capabilities (operational as well as dynamic) and different knowledge categories. It seems that operational capabilities fit most naturally with the category of pragmatic knowledge, whereas dynamic capabilities can be related to the category of conceptual knowledge and associated attributes.

Finally, in Section 4, the article presented a mapping of structural and behavioural features of networks and VEs into the resource and capability ontology model and identified network and VE capabilities, DCs and resource instances.

References

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Notes
1 Holdings of obvious market value (for instance real estate), or harder-to-measure value like aging equipment.
2 Other entities considered a resource by accounting conventions but may or may not have a realisable market value, such as goodwill (the value of a business to a purchaser over and above its net asset value). Goodwill reflects the value of intangible assets, like reputation, brand name, intellectual property, good customer relations and high employee morale, which improve the company’s business.
Knowledge based (resource and capability) ontology for virtual enterprises

3 Note that owned resources are a part of the organisation’s assets. Assets are items on a balance sheet considered to have positive monetary value and show the book value of property. Besides resources, assets include inventory and cash.

4 Note that company-specific resources cannot be leased or acquired on the market.

5 Such as in employment contracts.

6 Function is a term often used in industry to collectively label a domain of processes that need similar types of skills, resources, and knowledge, such as maintenance, accounting and manufacturing.

7 A domain is a functional area achieving some goals of the enterprise (e.g., sales, purchasing, R&D, production). A domain is composed of stand-alone processes.

8 Imitation occurs when firms discover and simply copy a firm’s organisational routines and procedures.

9 Replication involves transferring or redeploying competencies from one concrete economic setting to another.

10 Emulation occurs when firms discover alternative ways of achieving the same functionality.

11 In biology, endemic organisms are restricted or unique to a locality or region (to particular conditions in the environment).

12 Canon, for example, produces a wide and diversified portfolio of end products from binoculars to calculators, cameras, camcorders, copiers, document management systems, faxes, medical products, picture management, printers, scanners, security lenses, Visual Communication Systems, etc. At first sight, this seems to be an extremely wide portfolio of unrelated businesses. However, from the perspective of underlying core competencies, Canon relies on a much smaller set of core competencies in the area of optics, microprocessor control and imaging.

13 Learning is a capability by which repetition and experimentation enable tasks to be performed better and quicker. Learning, of course, involves organisational as well as individual skills.

14 Knowledge Management (KM) incorporates different KM methodologies, concepts, tools, reference models, technologies (all classified as resources) and routines with the mission to formalise and spread organisational knowledge. KM includes different activities and processes as for instance: (a) knowledge externalisation (from internalised to externalised knowledge), (b) knowledge formalisation (from tacit to explicit) and structuring (from unformalised or unstructured to formalised or structured knowledge) and (c) knowledge distribution and reuse.

15 Management (in this context) is the ability to efficiently and effectively coordinate internal and external activities and the use of resources to support change processes.

16 Leadership capability (in this context) is the ability to effect strategic change by effectively influencing the commitments of people.

17 Externalised and formalised capability can make it available for its replication or just for training purposes. In the case of the capability transfer, capability must be subsequently internalised otherwise it cannot be performed efficiently.

18 In terms of installing any needed ICT systems, training of personnel, etc.

19 Company-specific resources could be a deliverable of company capabilities (e.g., specific, own developed technology, machines, computer software or a created, well known brand name). These could also be ‘environmentally’ conditioned like locational or institutional assets (public policies are recognised as important in constraining what firms can do). Locational assets, for instance, represent a specific company location in a certain geographic market from which the company gains low transportation costs, fast response on market demands or improvement of other key success factors.