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Charting Process-Based Collaboration Support in Agile Business Networks

Aligning the Need for a Dynamic Internet of Processes from Industry and Research Perspectives

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Abstract: Agile business networking is an emerging concept aimed at helping companies face the challenges of the dynamic economy of the 21st century. It integrates a technology and a business perspective, arriving at highly dynamic internet-based processes. Despite its importance, there is no common understanding of this concept: many different interpretations exist leading to ad hoc business requirements or technical innovations. This creates confusion in research, development and application, and possible misalignment of requirements and solutions towards the future. In this paper, we set clear lines in this playing field by defining a configuration space for dynamic, process-based business collaboration, analyzing technology push and demand pull forces, and confronting these forces for alignment. To help new research efforts, we outline an approach to properly position them. Thus, we aim at contributing to a well-structured development of a dynamic Internet of Processes.

Keywords: Agile Business Networking, Dynamic Service Orchestration, Internet of Processes.

Setting the scene of agile business networks

Today's economy sees an advent of intensive business-to-business collaboration in networks of autonomous business organizations that deliver complex products and services to customers. Global competition drives individual companies into their core competences. Consequently, inter-organizational combinations of competences are required to deal with this complexity. To achieve effectiveness and efficiency in the resulting collaborative business networks, the operations of the participating organizations need to be tightly synchronized in the form of business processes (or service orchestrations), leading to business process networks [Ga10]. Tight process synchronization has contributed to developments such as on-demand business, just-in-time logistics and demand chains. They all reflect that the modern economy creates increasing levels of business network complexity.

Complementary to this increasing complexity is the increasing need for agility in business operations. This takes the established concept of dynamic capabilities [Ei00] to the business network level. Mass-customization of products and services, for instance, builds on the dynamic adaptation of the processes that produce them. Effectively dealing with external events in business operation, like fast market developments and unanticipated technology adoption, implies being able to deviate from previously set execution plans. Producing evolving products in fluid markets requires adapting the way processes and services are defined and executed. In summary, modern economy requires business agility powered by the ability to dynamically adapt business operations: dynamism is the basis for agility. Gartner stresses the importance of dynamic business process management for companies to deal with 'increasingly chaotic environments' [Ga10]. Advanced information technology needs to accommodate for this development. The German Industrie 4.0 initiative nicely illustrates this [GT14]. Building this technology on the Internet is essential to connect collaborating organizations.

The discussed developments – increasing complexity and agility – create both challenges and opportunities for industrial practice in many business sectors. Many organizations are struggling with their evolution to this new playing field, trying to overcome three hurdles. Firstly, many organizations are bound by their legacy in systems, processes, culture or staff. Secondly, the concept of agile networking can be interpreted in various ways and on various levels of abstraction, which makes the richness of design options for dynamic business process networks overwhelming. Thirdly, a clear map towards a future, fully dynamic playing field is missing, making it hard to determine which form and level of dynamism should be aimed at.

Complexity and agility in process-centered business collaboration also create a challenging area for integrating business and information technology, building a basis for the practical use of the *Internet of Processes*. Inspired by this, there have been many research efforts, leading to a broad spectrum of prototype approaches and systems. There is, however, no clear cohesion between these efforts, as they are based on a wide variety of assumptions, concepts, technologies, application domain characteristics, and funding opportunities. This diversity in emerging approaches and technologies is a major hindrance for proper understanding and well-structured application of a dynamic Internet of Processes.

In this paper, we describe the spectrum of dynamic collaboration in agile business networks, both from the requirements pull (industry) and technology push (research) perspectives, such that this spectrum can be used to chart developments. To this end, we analyze the state-of-the-art in industrial application domains and in research developments. The analysis tool that we use is the *dynamism cube*, which helps plotting current trends and desirable positions. This way, we provide a map that business architects and technology developers can use to better understand what is ahead in the world of dynamic process collaboration.

In the following, we first outline our main concepts and set up the dynamism cube. This cube is then used to plot *dynamism trajectories* for industry application domains. To analyze existing research efforts, we plot a set of these into the dynamism cube. Next, we confront these requirements pull and technology push perspectives to analyze their alignment. Finally, we describe an approach to systematically describe future research plans that explicitly take this alignment into account for proper target positioning.

Setting up the dynamism cube

With the term *business network* we indicate a set of autonomous business organizations that engage in operational collaboration to achieve a specific operational business goal. This collaboration is implemented in an *inter-organizational business process*. In the service science domain, the concept of *inter-organizational service orchestration* is used. In this paper, we treat both concepts as synonyms: they implement synchronization of activities or services in business networks.

An *agile business network* is a business network that can effectively and efficiently change the structure of its operational collaboration to comply with changes in its environment, either changes that have occurred or changes that are foreseen. To be agile, a network needs to have mechanisms for *dynamism* built 'into its genes', i.e., into its core operational infrastructure.
In this context, faces of dynamism range from *design-time* to *run-time*. Mechanisms for design-time dynamism support the application of changes to a collaboration before it is put into action. Mechanisms for run-time dynamism support on-the-fly application of changes to collaborations that are being executed. Both kinds of mechanisms are based on two main principles: the selection of a collaboration structure from a set of existing variants, or the definition of a new collaboration structure.
To describe the configuration options of business agility and mechanisms for dynamism, we set up a space in which we place concepts and mechanisms. We use a three-dimensional space that describes the main characteristics of dynamism in business collaboration: the *timing*, *scope*, and *topology dimensions* of dynamism, as shown in Figure 1. The dimensions have been identified using an interrogative-based approach [Gr16], as used also in the design of the Zachman framework of enterprise architecture [Zac02].

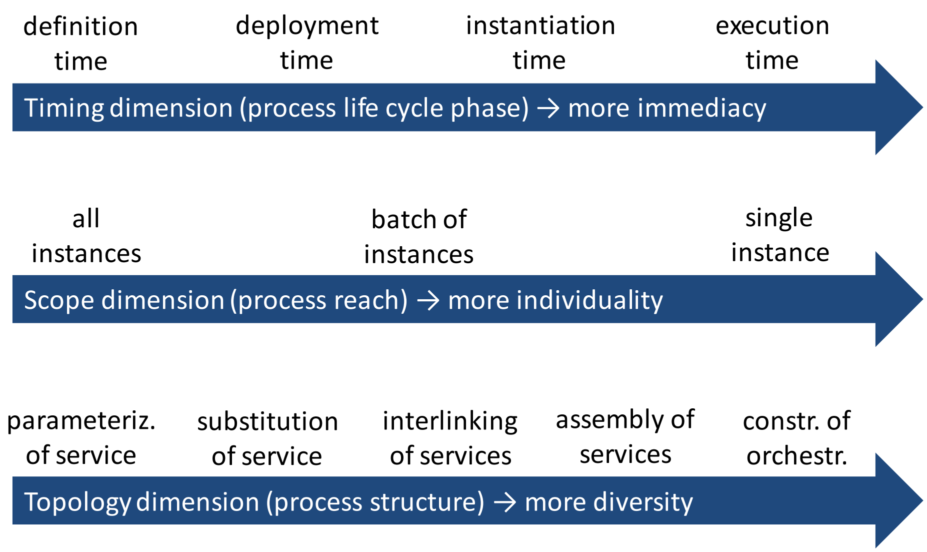

Figure 1: the three dimensions of dynamism

The *timing dimension* describes *when* changes can be applied, i.e., the level of *immediacy* of dynamism. The values in this dimension are based on the life cycle phases of collaborations: *definition time*, *deployment time*, *instantiation time*, and *execution time*. One can refine this dimension by including values like *contracting time* (pre-deployment) or *evaluation time* (post-execution), but for the line of reasoning in this paper this does not add much. The *definition time* value is the least dynamic, the *execution time* value the most.
The *scope dimension* describes *what* is affected by changes, i.e., the level of *individuality* of dynamism. The main discriminator here is the type level versus the instance level of collaborations: the former covers *all instances* of a specific type of collaboration (such as the handling of all customer orders); the latter covers a *single instance* of collaboration (such as the handling of a specific customer order). In between, we identify a *batch of instances*, which is a qualified set of instances

(such as the handling of all customer orders in a specific month). The *all instances* value is the least dynamic, the *single instance* value the most.

The *topology dimension* describes *which* structures of collaboration can be changed, i.e., the level of *diversity* of dynamism. The five values in this dimension are less obvious than those in the other two, but they are needed to describe how 'intense' changes to a collaboration can be. The *parameterization of services* value indicates that only parameters can be changed in a predetermined collaboration structure, for example quality-of-service parameters. The *substitution of services* value means that parts of a collaboration can be substituted by isomorphic parts that are provided by different providers: actors can be changed, but the structure of an orchestration cannot. The *interlinking of services* value means that collaborations can be changed by creating new links between pre-existing constituent parts that 'fit' in their interfaces. The *assembly of services* value allows creating links between pre-existing constituents parts even if their interfaces do not 'fit' - requiring the insertion of adapters in the links [Br06]. Finally, the value *construction of orchestrations* means that arbitrary orchestrations can be created from the elementary services in a network, i.e., completely new collaboration parts can be created. This is the most dynamic value.

We have designed the three dimensions to be fit for practical use, obeying the principles of *orthogonality* and *subsumption*. Orthogonality means that values in the three dimensions can be chosen independently from each other, making all combinations possible in principle. Subsumption means that we use ordinal scales for the dimensions with values that subsume 'lower' values on the scale. As an example of subsumption, we observe that a collaboration with the *batch of instances* value in the *timing* dimension can also handle the *all instances* case (by having a batch with an empty qualification). Note that more dimensions are possible, like the *origin* dimension that described *who* initiates a change in an orchestration.

To visualize the concepts, we plot the three dimensions in a *dynamism cube* that is used as a three-dimensional map in which technology solutions and industry requirements can be allocated. This cube is shown in Figure 2. Each cell of the cube contains a combination of the values in the three dimensions. At the bottom-left-front corner of the cube we have the lowest level of dynamism and at the completely opposite corner the highest level.

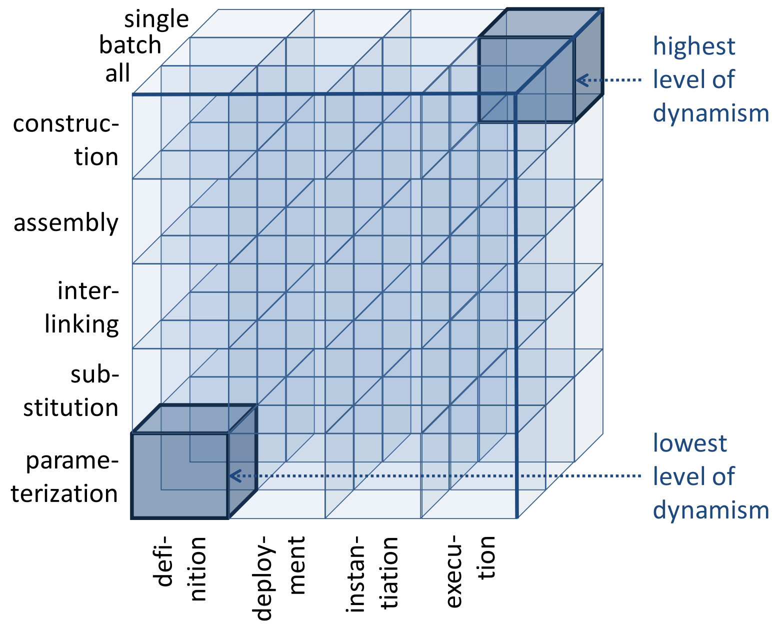

Figure 2: dynamism cube

There are trends towards more dynamism, both in industry applications and in technology developments. The question is, however, what the exact nature of these trends is and how they relate to each other. In the next two sections, we answer this question by charting the requirements pull developments from business and technology push developments from research in the dynamism cube.

Charting industrial dynamism trajectories

Many industry sectors are moving towards a future with higher levels of dynamism [Ga10, ID14, GT14]. The question is, however, what these developments concretely mean for shifting requirements in the support for dynamism. We discuss this question by plotting these developments as *dynamism trajectories* in the dynamism cube, i.e., paths from the current usual combination of dynamism values to a projected future combination of values.

To illustrate, we have selected four industry sectors: the service industry, high-tech series manufacturing, mobility services and healthcare. We show the dynamism trajectories for these sectors in Figure 3 and explain them below. The exact details of each trajectory are subject to discussion, but the angles of the trajectory vectors are clearly pointing towards increasing dynamism.

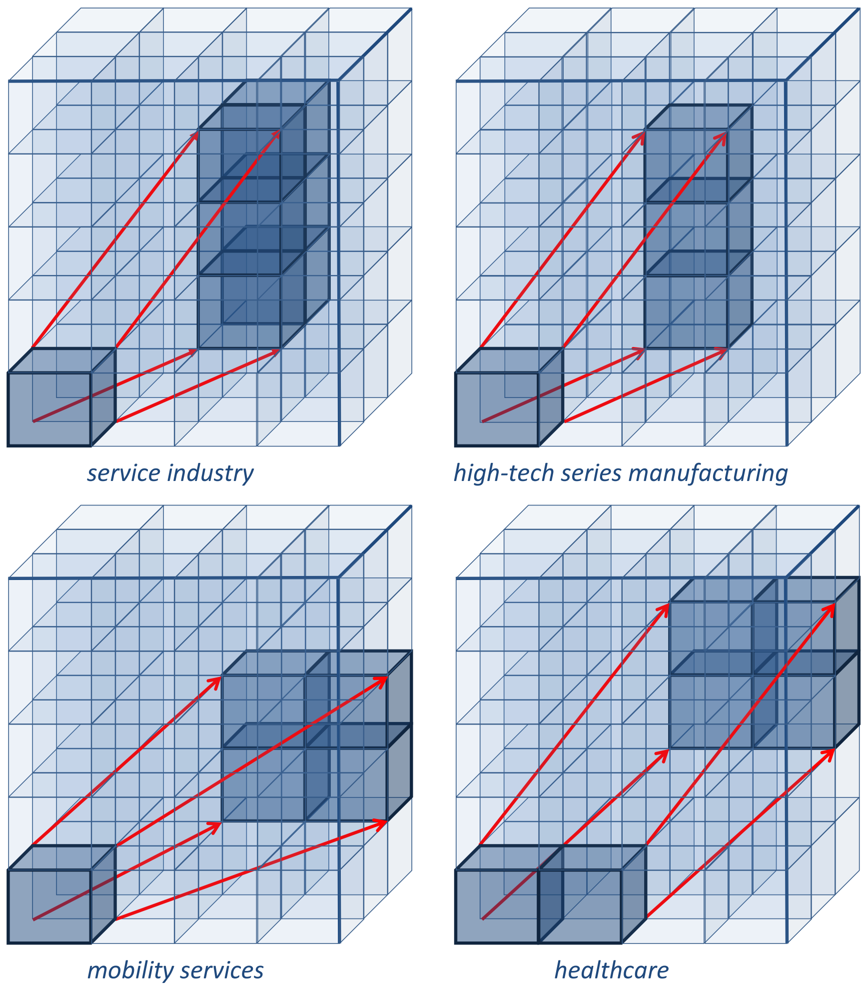

Figure 3: trajectories for several industry sectors

In the service industry, we see a trend from traditional static stand-alone services towards mass-customized integrated solutions. Examples of traditional stand-alone services are bank accounts and television channel provisioning, located in the least dynamic corner of the dynamism cube. Current innovative developments are per-customer individualized financial solutions and per-customer-segment tailored entertainment packages. This requires a change in the *scope dimension* from *all instances* to *single instance* or *batch of instances*. In the *timing dimension*, a change is required from *definition time* to *instantiation time*: exact customer solutions are determined at the moment they are activated. In the *topology dimension*, we need to move from *parameterization* of static collaborations to *substitution, interlinking* or even *assembly* of orchestrations. For example, in the entertainment industry, dynamic collaboration takes place between content providers, infrastructure providers and advertising providers.

In the high-tech series manufacturing sector, we see similar developments. Flexible collaboration models and inter-organizational business processes are receiving substantial attention [ID14], often technologically fueled by the *Internet of Things* [Lu16]. For many kinds of high-tech products, however, the future value in the *scope dimension* is limited to *batch of instances*: small series are produced for specific target groups, but not completely individualized products. In some industries in the high-tech manufacturing sector, the current starting point (and hence also the targeted future point) is more dynamic. This holds mostly for high-value goods production, like in the automotive industry, where cars are built-to-order and offer literally millions of different variants [Wa14].

In the mobility service sector, we currently often see disconnected services - for example in public transport, the orchestration is usually with the end user. There is a trend, however, towards highly integrated, individualized mobility solutions [Sc15]. In the *scope dimension*, the trend is from *all instances* to *single instance*, as every individual traveler follows a different route. In the *timing dimension*, the value moves from *definition time* (as in time table creation) to *instantiation time* (start of travel) or even *execution time* (change during travel). To allow for this, the value in the *topology dimension* moves from *parameterization* to *substitution* or *interlinking* - we do not foresee *assembly* or *construction* in a low-margin sector.

In the healthcare sector, we traditionally see a mostly static situation. Sometimes, possibilities exist for *deployment dynamism* in the *timing dimension*: orchestrations can be determined when they are deployed in specific situations. The more dynamic future situation is comparable to that in the mobility service sector, but we expect more dynamism in the *topology dimension*: complex medical treatments are more individualized than transport solutions, thus requiring *interlinking* or *assembly* of services. Given the pressure for efficiency in the costly healthcare sector, an increasing pressure towards standardization is observed, making *construction* a less desired value.

We conclude that there is a general trend towards more dynamism to support business network agility. The trends are different per sector, pinpointed by dynamism trajectories. The trajectories indicate the deltas per dimension that are required and hence should be supported by information technology. Therefore, we now move our attention from the requirements pull to the technology push aspect.

Plotting contributions of research efforts

We have seen new requirements from industrial practice for the support of dynamism to enhance agility in collaborative business networks. From the point of view of information technology research, there have been a number of efforts towards this support of dynamism. We analyze a set of these to see how their contributions can be plotted in our dynamism cube.

As with our exploration of industry sectors, our purpose is to analyze a representative set of research projects here. We observe trends that can be the basis for further analysis (and possibly planning, as we will see later). We have chosen a sample of projects that address structure and dynamism in business collaborations and that satisfy criteria making them relevant here: an explicit aim at supporting business networks, an involvement of multiple parties, a practical application goal, and publications in an international research setting. Table 1 shows an overview of our set of projects, based on a detailed analysis of these [Gr16]. As an example of how to read this table: the ADVENTURE project addresses *instantiation* and *execution time* in the *timing* dimension, *single instance* in the *scope* dimension, and *assembly* and *construction of services* in the *topology* dimension. We take the starting year of a project as a meaningful reference to its period in time, as the concept of a project is typically defined then.

Project	Start	Timing				Scope			Topology				
WISE	1998	■				■					■		
CrossFlow	1998		■		■		■	■		■			
XTC	2003	■				■					■		
CrossWork	2004	■					■			■	■		
SYNERGY	2008				■			■					■
CoProFind	2009	■				■					■		
ADVENTURE	2011			■	■			■				■	■
C3Pro	2011	■			■			■					■
ComVantage	2011	■				■					■		
GloNet	2011		■			■						■	
GET Service	2012	■			■			■			■		

Table 1: research projects in sample

In Figure 4, we have plotted the sample of projects in the dynamism cube, labeled by their starting years. There are more markings in cells than projects, as some projects cover multiple dynamism paradigms (see Table 1). An example is CrossFlow, which explicitly addresses the *batch of instances* and *single instance* in the *scope dimension* [Gr16]. Some projects have the same combination of values, leading to multiple labels in the same cell of the cube. We have color-coded cells to help interpretation: blue cells are in the front, green cells in the middle and orange cells in the back vertical slice.

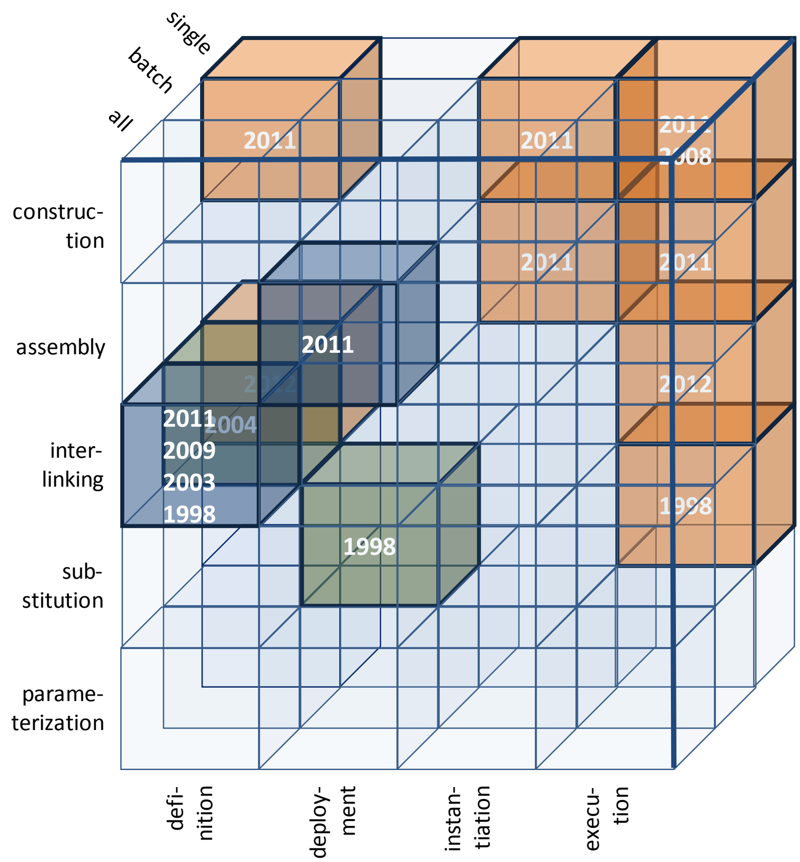

Figure 4: research efforts plotted in the dynamism cube

When we take a good look at Figure 4, we can observe the following. In the *timing dimension*, we see 'old' and 'new' projects at both extremes, i.e., the left and right sides of the cube. This also holds for the *scope dimension*: we see 'old' and 'new' projects both in the front and the back of the cube. In the *topology dimension*, there is a light trend towards more dynamism through the years, though this trend is not consistent: some of the most recent projects appear at the middle value (*interlinking*). From this, we draw the conclusion that there is no clear *technology trajectory* in the development of support for agile business networks.

This may be explained by the fact that many research efforts are essentially driven in their content by 'local' technological curiosity, researcher background, and possibilities for funding. Many projects are coupled to application sectors in their definition, but the technological concept is often settled (in the project plans) before a detailed requirements analysis in the sector has been completed (in the first phase of the execution of the project).

Consequently, research efforts lead to many nice results, but often of an ad hoc (project-specific) nature. This means that the possibilities for 'accumulation' of results towards generally usable technology platforms for support of dynamism are limited.

Aligning the perspectives and getting to better research project plans

In the previous sections, we have plotted dynamism trajectories for industry sectors (requirements pull) and we have analyzed a sample of research efforts aiming at supporting dynamism in business networks (technology push). An overall technology trajectory cannot be distilled from our analysis of research projects. Mapping individual research projects to general industry requirements may likewise be impossible. Mapping existing research projects, or maybe more importantly envisioned new projects, to dynamism trajectories of specific industry sectors is more pragmatic. To illustrate this, Figure 5 shows a confrontation of the high-tech series manufacturing dynamism trajectory (from Figure 3) with the classification of the CrossWork project (from Figure 4), which explicitly aimed at providing a solution for dynamic collaborations in the automotive industry [Gr09].

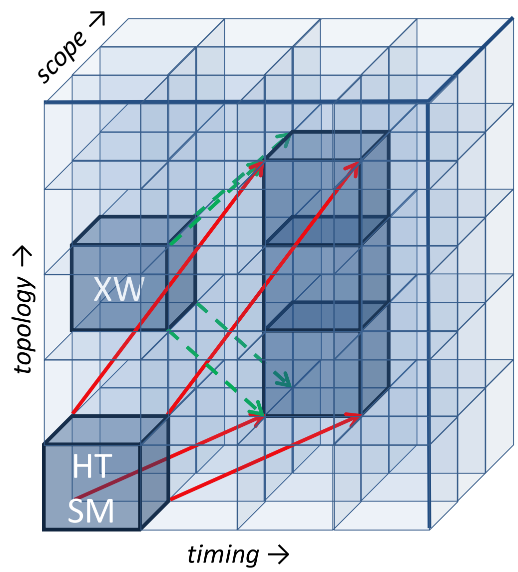

Figure 5: high-tech series manufacturing (HTSM) trajectory confronted with CrossWork (XW) project

The dotted arrows in the figure show the 'main mismatch' in the mapping: in the *timing dimension*, the CrossWork project aligns with the current situation, not with future requirements. In the *scope dimension*, the project is positioned well. In the *topology dimension*, extension is required. Consequently, in hindsight the project could have been positioned such that it would have better addressed the dynamism requirements of the application domain.
To achieve good positioning of new research projects, the following steps can be followed:

1. *Identify the targeted application domain(s) for a project.*
2. *Plot the dynamism trajectory for these domain(s) in a dynamism cube.*
3. *Identify existing research projects (or commercial technologies) that coincide with the target of the dynamism trajectory.*
4. *Design the research project such that it is positioned at the target of the trajectory not covered by Step 3, but able to integrate solutions identified in Step 3.*

In doing so, future projects will be better aligned to actually address the 'blind spots' of collaboration support in agile business networks. This alignment with both practice and research can be taken as a good starting point for design science research [He04], which is a basis for research on systems for business collaboration support.

Conclusions

We want to set requirements owners in the area of dynamic business networks and developers of networked business process technology to think about a well-structured framework for aligning what is needed and what is developed. This contributes to an Internet of Processes that can truly be used by modern business. Our dynamism cube is a first step in this direction. Before requirements and developments can be mapped, they need to be charted first. This can be achieved by explicitly positioning (future) applications and (future) systems in the three dimensions of dynamism that we have identified.

In follow-up work, we plan to provide a more extensive analysis of the requirements of business sectors. This will be the basis for a detailed confrontation of requirements pull characteristics (industry dynamism trajectories) and technology push characteristics (research effort classification). We plan to aggregate positions of research efforts targeted at specific sectors, such that we can perform an overall gap analysis of the state-of-the-art in specific sectors.

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