COLLABORATIVE NETWORKS SUPPORT SUSTAINABLE BUSINESS SETTINGS REGARDING INTEGRATION OF DESIGN AND CONSTRUCTION.

JAN WORST
Maastricht School of Management
worst@msm.nl

Abstract
Integration of design, engineering and construction (D-E-C) aligned to collaborative networks (CN's) is about overcoming traditional barriers. Collaborative Network systems are submitted to economic, social and environmental circumstances. D-E-C integration linked to CPFR and submitted to CN's could bridge traditional barriers, when aligned to an agreement and a joint business plan. CPFR contains four levels and eight collaborative tasks and was initiated and co-led as CFAR by Wal-Mart in 1995. CPFR offers entrance to a synchronized process and identified partners submitted to a joint workflow management system. Limits to arrive at D-E-C integration are indicated by defining ontology (a theoretical model) on interdisciplinary activities.

Keywords: collaborative networks, D-E-C integration, CPFR, ontology, identified.

INTRODUCTION

Collaborative networks (CN's) are systems of legally independent partners in industries and services to cooperate on shared economic sense. Partners coordinate and communicate in changed business paradigms that use systems supported by Service Oriented Architecture (SOA) often aligned to web-based services. Collaboration structured through CN's offer the opportunity to enlarge capacity, reinforcement of capabilities and market strength. Due to traditional business settings the barriers are high to enter CN's such as virtual enterprises [Worst, 2009]. According to PwC [2005] firms participating in collaborative networks consider their investments in ERP environments crucial and cherish traditional ICT configurations. Following Sterman [2000] single-loop learning models such as the construction process will use one existing mental model to reach their goal. For instance: The Constructon case [Project Pact, 2004] indicates that unchanged mental models block collaboration. Constructon [2004] was initiated as a pilot project to find a solution on the construction industries' supply chain mismatch. The project was introduced by Constructon to establish virtual enterprises. Constructon initiated a link to ConstrucNed Technologies, which provided web-based services. The main goal was to reinforce integrated co-operation cross the construction supply chain by embedding web-based services. Adoption of e-commerce in combination with business process reengineering (BPR) was addressed as the key to new business settings to arrive at competition on quality instead on price. The key to success was focused on synchronizing business processes within and across project partners to elevate efficiency and effectiveness. The initiative was supported by earlier studies on virtual enterprises of CSTB France [Zarli et al. 2002] and European platforms such as RoadCon, Manubuild, and the OSMOS project [Worst 2004, 2009]. Hosted databases and data warehousing connected to web-based services were introduced in 2006 by ConstrucNed Technologies [2006]. The pilot project ended in 2008 due to lack of support. Although virtual business settings reinforce concurrency in the construction process, it is difficult to arrive at a synchronized process. In particular new roles, functions, and transparency block change of traditional business settings. Integration of design, engineering, and construction requires change of mental models and operational management.

PROBLEM

Considering collaborative networks and D-E-C integration, the following questions are of importance to find a solution:

- How do the construction industry and its adjacent markets cope with collaborative networks to regulate competition and transparency?
- How do partners in a construction project organize collaborative assessment of partners in networks?
- Are collaborative networks adopted by governments, industries, supportive industries, public services and private services? Are they legally supported by current national and international law?

Objective of this paper is:

- To identify ontology of collaborative networks focused on integration of design, engineering, and construction.
- To describe a CPFR model aligned to collaborative networks focused on integration of design, engineering and construction.

Collaborative Networks (CN's): CN's operate legally almost as real firms. CN's represent connected participants opting for one goal. For instance they represent a virtual enterprise, when partners are legally bound, and share economic sense and ideas about economics, environment and social responsibility. Participants are legally independent firms underwriting a contract that settles a code of conduct and rules of engagement. Architects, engineers, contractors, suppliers and subcontractors aligned to a CPFR-model have to accept new roles in the construction process. Do CN's have legal foundation according to domestic law of member states, when looking at the EU? Yes, for instance assets of CN's are e.g. concessions to build, which indicates liability to contracts. Economic, Social and Environmental factors regarding the opportunities CN's offer are currently not an issue of business strategy in the West European construction industry, although the many opportunities CN's offer.

Integration of design and engineering requires a network organization that links investment decisions, marketing, object design, engineering, and execution of processes. CN's submitted to a synchronized process contribute to increase efficiency in mobilization and allocation of design, logistics and engineering. CN's contribute also to reduction of inventory, transportation, and logistic costs. CPFR is a business model to enhance collaboration. To start collaboration, Leeman [2010] indicates CPFR (collaboration, planning, forecasting, and replenishment) as a business solution. It provides guidelines to start up collaboration. The CPFR-model encompasses an opportunity to start up synchronized processes to arrive at design D-E-C integration. It means that investor, marketers, architects, engineers, contractors and suppliers have a legal understanding based on an agreement and a joint business plan.

CPFR began in 1995 [Wikipedia, 2011] as an initiative co-led by Wal-Mart. Originally it started as a model on collaboration, forecasting and replenishment named CFAR-model. CFAR was presented to the Voluntary Interindustry Commerce Standards Committee (VICS). CPFR was [Leeman 2010] developed by the VICS organization since 1998 and is similar to the ideas about the virtual enterprise described by Worst [2009]. In 1998 VICS initiated a roll-out of CFAR as an international standard, which was published in 1998 as CPFR voluntary guidelines and followed by CPFR Technical Specification in 1999. At first CPFR was a 9 data flow process. CPFR was seen by VICS [1999] as a "platform- and vendor independent environment, where multiple parties can operate". "Partners of different sizes and technical levels can collaborate through accessible technologies, including Internet, and the Web, private Value Added Networks, or transport networks".

Since 2005 VICS describe CPFR as a model that exists of four levels encompassing eight collaborative tasks. CPFR is a licensed tool managed and registered by VICS [Overview May 2004]. Following Prasad [2002] CPFR was initiated to reduce inventory and save on organization of material distribution (time to consumer). However, the projected benefits were not realized due to badly shared information between suppliers and retailers. Induced by lack of visibility replenishment programmes were not realized. CPFR could be disruptive to traditional business paradigms. For instance, collaborative networks such as virtual enterprises [Worst 2009] adopt according to their definition the CPFR-model. Of utmost importance for individual partners is to overcome a cultural lack and ICT time-lag. CPFR is according to Prasad adopted in varying degrees by other industries, although it is assumed best working in consumer good's industries. The following matrix diagram (figure 1) indicates the relation between efficiency and effectiveness when opting to arrive at CPFR level..

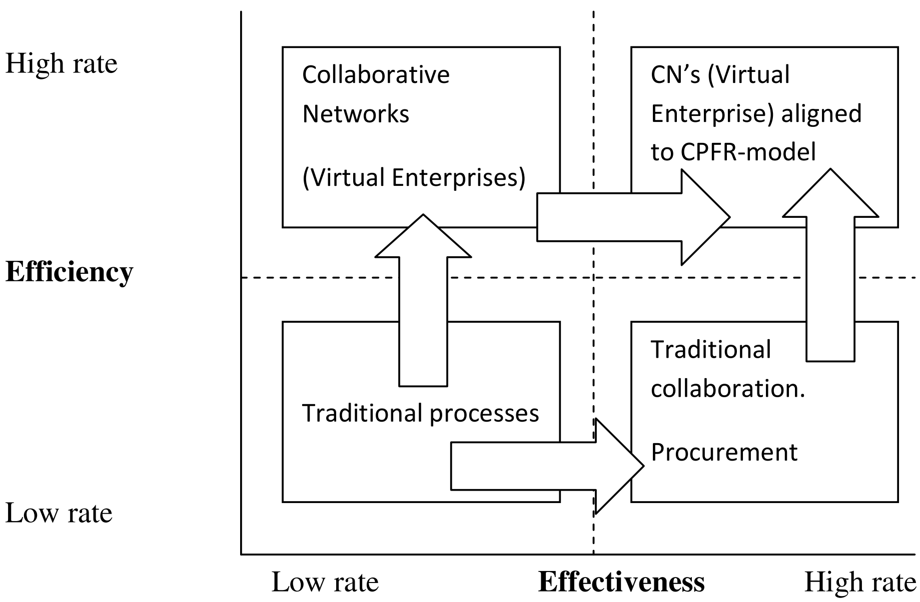


Figure 1: Matrix diagram indicating arrival at CPFR-level.

Arrival at CPFR level is possible by opting for collaborative networks encompassing the CPFR-model, or breaking with traditional procurement policies. Investors, architects, engineers and contracting engineers have an agreement containing: (1) a joint project focused business plan, (2) forecasting objects'exploitation, (3) planning of design, (4) engineering, and construction, (5) delivery plan, (6) guarantee and maintenance, (7) construction monitoring and (8) performance assessment. By developing and implementation of exception management as part of performance management, strengths and weaknesses of the partnership are identified. Following the previous steps, efficiency will be enhanced, because the process is based on transparent and synchronized operations supported by WorkFlowManagementSystems (WFMS). A common catalog eliminates inconsistencies in trading partners and product/service identifiers. CFPR, when aligned to web-based services offers an opportunity to a synchronized process. Effectiveness will increase due to transparency to all trading partners including design and engineering. In fact, it is a metamarket focused business model, which increase capacity and clear product and service identifiers to all partners. Access to on line procurement of selected and identified partners. Access to a large community of selected and identified partners. Table 1 point at the benefits of CPFR, when D-E-C integration is involved.

Table 1: Benefits, when opting for CPFR to support D-E-C integration

Participant:	**Product demand:**	**Economic:**	**Process:**
Investor/Buyer	Clear point of buying. Clear point for rental.	One price; Fixed DBMOT guarantee.	Synchronized. WFMS.
Architect/Engineer	Clear objective. Approved theme.	Identified products and services.	Synchronized. WFMS
Suppliers	Clear specifications.	Stable work flow. Stable cost-benefit.	Synchronized. WFMS

Looking at the three basic factors [Worst, 2009; pp. 17 to 29] of collaborative networks tables 2, 3 and 4 indicate general strengths and weaknesses. Although the opportunities (including strengths and weaknesses) of the supply chain are known, integration of design, engineering and construction is only possible, when an agreement on collaboration is created and interfaces between all participants are submitted to Service Oriented Architecture (SOA) aligned to web-based services.

Table 2: Economic factors in the context of domestic economic situation.

Economic factors.	Western Europe	Eastern and Mediterranean Europe	USA	BRIC	Developing Countries
Enlargement of capacity on Skilled Labor Force	Domestically diminishing enforced by East European labor force.	Domestically diminishing, because of high payment in Western Europe.	Travelling labor force over the continent.	Training and import from abroad.	Not available. Training programmes are required.
Enlargement of manufacturing capacity on prefabricated elements.	Limited capacity regionally controlled by MNE's.	Limited capacity controlled by domestic suppliers and MNE's.	Limited and controlled by large firms such as MNE's.	Limited and controlled by domestic suppliers.	Small, traditional and domestic.
Doubling of Equipment capacity	Limited and controlled by large suppliers.	Limited and controlled by large suppliers and MNE's.	Limited and controlled by (MNE's)large suppliers.	Limited and controlled by large suppliers.	Import.
Enlargement of Building materials' resources.	Resources controlled by large suppliers.	Resources controlled by large suppliers and MNE's.	Resources controlled by (MNE's)large suppliers.	Resources controlled by domestic suppliers.	Domestic and import.
Double capacity of web-based services.	Partially explored.	Partially explored.	Partially explored.	Partially explored.	Partially explored.

Double D & E capacity.	Export of methods and knowledge.	Domestic plus import.	Architects are often leading consultants.	Domestic plus import of leading consultants.	Import of methods and knowledge.
Double Financial capacity.	PFI and PPP require solvent partners.	PFI and PPP require solvent partners.	PFI in cooperation with private sponsors.	Private, PPP and FDI	FDI
Increased transparency	Tenders on Capacity and Concessions.	Tenders on Capacity and Concessions	Tenders and concessions.	Tenders and concessions.	Tenders and concessions.

Table 3: **Social factors in the context of domestic situation.**

Social factors	Western Europe	Eastern and Mediterranean Europe	USA	BRIC	Developing Countries
PPP and PFI's	Political instruments.	Cutting budgets?	Cutting budgets is necessary	Economic growth offers budget growth	Depend on FDI initiatives
Cross cultures	Industrialized states.	Partly industrialized.	Multi-cultural	Industrializing.	Natural resources.
Responsibility and Accountability	Accept PFI's and PPP's	Proper use of PPP's and PFI's	Private funding	PPP and FDI instrument	UN i.c.w. FDI
Reinforce Equity	Current low profit margin.	Current low profit margin.	Current low profit margin.	Economic growth boosts local margins.	No margin to realize trade-offs.
Social security	Pension plans burden.	Pension plans burden.	Health care insurance.	New regulation required.	No insurance.

Table 4: Environmental aspects in the context of domestic situation.

Environmental factors	Western Europe	Eastern and Mediterranean Europe	USA	BRIC	Developing Countries
Stable Natural resources	Import by MNE's	Import by MNE's	Controlled by MNE's.	Domestically controlled	Controlled through FDI
Pollution	Kyoto	Kyoto	Non Kyoto	Kyoto?	Kyoto?
Ecosystems and sustainability	EU regulation?	EU regulation?	Dispersed regulation?	Dispersed regulation?	Regulation at all?
Collaborative Logistics	Civil law is different between domestic markets.	Civil law is different between domestic markets.	Civil law is different between states.	Civil law is not equal to Western Europe.	Civil law is often absent.

CN's are confronted with legal and cultural constraints. Therefore CN's could be of importance, when investors initiate new projects and are operating on different domestic markets submitted to different regulation and business culture. The tables 2, 3 and 4 indicate also aspects, that influence not only design, engineering, and construction, but investment, marketing, procurement and financial engineering too.

Crucial in communication between partners is the intention and rationale of architecture. Electronic-concurrent engineering [Mesquita et al. 2002] provides a solution to cope with information sharing to arrive at integration of design, engineering and construction. In line with Love [1997] Mesquita et al. mention the fundamentals of concurrent engineering such as multidisciplinary teams and execution of concurrent product development during different stages of the process. It affects integration of roles of different players during the process. By briefing [Caballero, 2001] of all partners during the design stage, it is possible to initiate a creative learning, which affects interfaces such as: client - architect; client – engineers; architect – engineers; engineers – suppliers; and engineers - contractors. Poor adoption of concurrent engineering by participants of collaborative networks in the construction industry is one reason for low correlation between firms' strategy and operational management (see attachment). Low correlation occurs, because the engineers use communication technology in a unstructured way and without any ranking of data and relationship with workflow management systems (WFMS). To all partners involved in the supply chain adjusting information is crucial (see attachment).

How do you transmit information in the form of single data, meta-data and documents? Not only during the kick-off of a project, but during the whole process. Considering the fragmentation of the industry Caballero et al. [2001] defined an information model, which is similar to portal models supported by web-EDI.

Strategy focused on entrance of CN's is informal, but when aligned to CPFR formally guided. According to Menardi [2010] strategies became relatively formal since the 1960's for two reasons: "(1) The increasing amount of available data on business costs and operational performance; and (2) The uncertainty and anxiety that available data cause. No company could be sure it went on top." Actually, analysis has a retrospective effect and not a pro-active. So the insights of successful strategies are not known. Since the 19-nineties strategy of construction firms [Worst, 2001] was based on acquisition to reinforce construction capacity and being best cost provider.

ICT Strategy focused on replacement of existing system architectures was low. However, according to the Economist (issue dated 18th March 2011) firms have to focus on vertical integration, which means integration of IT hardware, operating systems and applications such as ERP aligned to web-based services aligned to SOA, and applications. In particular computer giants such as Dell and HP are currently competing on the previous mentioned vertical integration due to the overwhelming success of Apple's iPad.

Business strategy, when aligned to collaboration, has no significant correlation with connectivity through the web. Following Worst [2009] the reason is and was that top management considers investments in web-based solutions not in line with the investments in their ERP environment. The pay-off of investment in a virtual environment takes a long time. Currently the effects of the economic crisis and slow economic growth reinforced thinking about the benefits of collaborative networks.

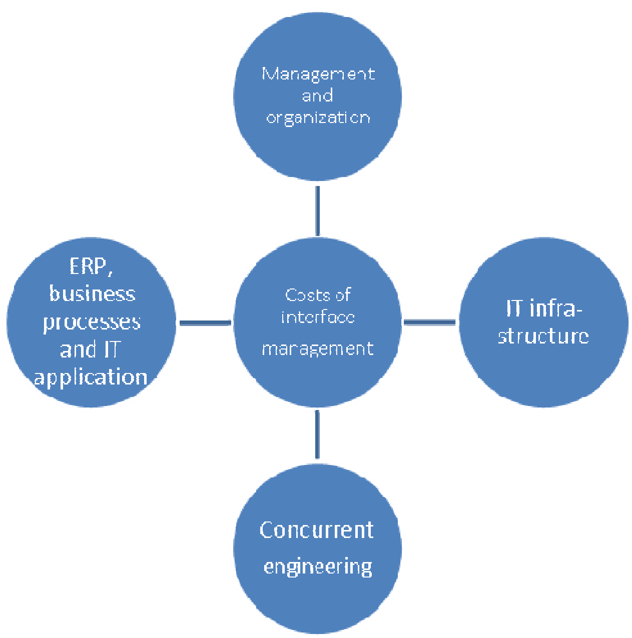


Figure 2: Sustainability and stability considering the cost of controlling interfaces.

Information, communication and integration: Integration of design, engineering and construction will be accelerated, when use of structured exchange of information and communication is organized through use of web-based solutions and SOA. Current development of technology to control interfaces and data exchange, offers support of high quality to systems supporting CN's. It is of utmost importance according to Derksen et al. [2009] to measure the stability of current IT infrastructure, the number of interfaces and the costs of communication and sharing information. Figure 2 indicates costs of interface management given the level of stability between management and organization, business processes, ICT configuration, and acceptance of concurrent engineering. The main question is: What investments need to be made to arrive at a level that firms can fully participate in CPFR driven CN's?

Partners of CN's are considered to be aware of business model stability. So, establishing CN's requires adoption of web-based services aligned to SOA. SOA is also aligned to integration of dispersed installed software such as Planning, CRM, HRCC, Accounting, logistics, and CAD. Firms have to look in the future. In particular to achieve balance (figure 3) between strategy, IT-infrastructure, management and organization and business performance. Partners must be able to respond to CPFR guidelines encompassed in the collaboration agreement next to exception management, which is aligned to performance assessment.

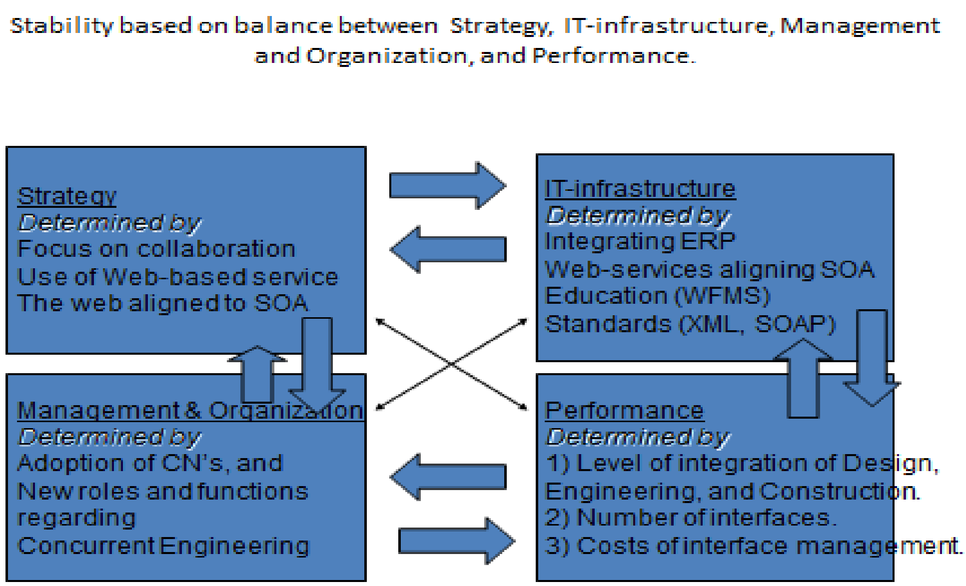


Figure 3: IT Investment focused on balance between strategy, IT-infrastructure, Management & Organization and Performance [source Worst, 2009].

Ontology defining the logical theory of models regarding CN's requires a set of relevant relations. These relations consider aspects of strategy and planning; forecasting; execution; and performance and analysis. Contracts such as BOT; DBOT; DFBOT; DFMBOT and LBC are based on prognosis of project performance and often [Mesquita et al. 2002] subject of incomplete forecasting, because of unbalanced briefing on rationale of design. D-E-C integration of design is subject of research since the 19-sixties. Love et al [1998, 2002] described the barrier between design and construction as an important constraint. Love suggested cross discipline briefing in the construction industries' supply chain. Not only in the construction vertical (supply chain), but also in the construction horizontal (value chain).

Transparency is required to involve the customer, the user, the investor, contractor, sub-contractors and suppliers in construction supply chain management. To arrive at such point, the following principles are known and set to all partners:

- Synergy due to collocation of economies of scope and economies of scale.
- Openness in sharing information.
- Transparent workflow management systems (WFMS).
- Definition of the layers of communication such as: Chat, telephone call, conference, web-sphere communication, and or web-services?

Using the Internet to reinforce communication between managers requires a stable endogenous business environment when it concerns Web driven Electronic Data Interchange. Exogenous: the quality of the provider, claim of the CN's domain and hosting of web-based service are crucial to arrive at collaboration between client, architect, engineers, suppliers and contractors. As shown in table 5. Structuring collaboration and cooperation starts with alignment of all partners to the intent of design and its rationale. If not, disturbances between partners will occur during the process.

Table 5: Communication and sharing information through use of World Wide Web.

The web	How is openness of entrance to infrastructures and sources?
Provider(s)	Are they offering web-services to support collaborative networks?
Domain	Which domain-owners offer legal solutions to collaborative networks in construction or otherwise?
Hosting	How is hosting organized? By suppliers of web-based services, providers, domain owners?

Ontology: D-E-C integration and the assumption about reduction of cost of failure and low cost of interface management requires a philosophy, or a theoretical model (ontology). In computer science ontology is a technical term for an artifact designed for an objective such as modeling knowledge about a specific business. According to Liu and Özsu [2008] ontology comes from the field of philosophy concerning the study of existence. Their definition is as follows: "ontology defines (specifies) the concepts, relationships, and other distinctions that are relevant for modeling a domain". Osterwalder and Pigneur [2002] base their definition of ontology on four pillars. The first denoted as "product and services", the second as "infrastructure and the network of partners" necessary to create value. The third notation is "relationship capital", which refers to the sustainable contacts with the customer and the fourth refer to "financial aspects" such as cost and revenues. The virtual enterprise is according to its definition [Worst; page 11, 2009] an ontology, which has to fit with all participants' ICT capabilities.

A collaborative network encompassing CPFR aligned to a construction project could be defined as: a legally guided collaboration between legally independent partners in the construction process, to cooperate on shared economic sense, and to coordinate a construction exercise to build a single design, a combination of designs, or a concept using the Internet to communicate. This definition is broader than the ontology of the virtual enterprise (VE), which was based on coherence between strategies, culture (operational management), information technology and web performance of business models.

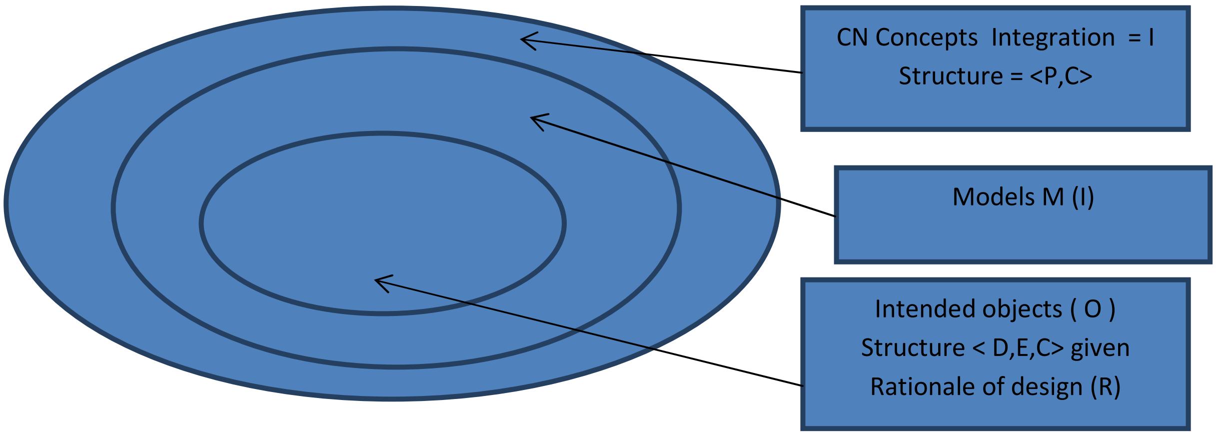
Each VE-model has the ability to be adopted by a participant in the construction process. Considering the ideas of Guarino (table 6), conceptualization of CN's has to be seen as a domain of D-E-C integration < I >. Collaboration through guidelines concerning CPFR is related to < P, C >. Given the limits of < P, C > conceptualization of a set of relevant relations affect the current state of affairs encompassing construction industry's fragmentation, and transparency. The engineering artifact is related to the consequences of fragmentation [Caballero, 2001] such as inadequate capture, structuring, prioritization, and implementation of clients' needs. Life-cycle aspects are absent and not subject of collaboration, integration, and coordination. Therefore data about design, engineering, prefabrication and construction of a project are not brought downstream to be readily reused.

Design intent and rationale are according to Caballero et al. [2001] poorly communicated. Such an attitude by all partners involved leads to unwarranted design changes, unnecessary liability claims, and increase of design time and inadequate pre- and post- design specifications. The conclusions about communication flaws during the construction process as shown in the Project Pact report [2004] adjust the conclusion of Caballero et al. Considering the analysis of Guarino [2008] we may in philosophical sense refer to ontology as a particular system accounting for a certain vision on the world. Guarino refers to Gruber [Guarino 2008], who defines ontology as a specification of conceptualization. Table 6 and figure 4 indicate ontology.

Table 6: definition of ontology regarding D-E-C integration (adapted from Guarino 1998)

Category:	Specification:
D-E-C Integration	CN's does not depend on particular relations regarding D-E-C integration.
Artificial Intelligence	Ontology is geared at an engineering artifact. This artifact is constituted by specific CPFR guidelines to describe D-E-C integration.
Relations	Explicit assumptions regarding the intended meaning of the relations, which have the form of a logical theory on managing interfaces.
Intended meaning	Depends on the relations plus the set of assumptions.
CN concepts regarding CPFR driven D-E-C integration.	I is a domain of projects' D-E-C integration C is a set of CPFR guidelines on P D-E-C integration is a concept, which defines domain I structure <P,C>. A domain is collocated with projects (P). Collaboration (C) aligned to integration requires an object and specifications (o); guidelines (g); a synchronized process (s); and a workflow management system (s). So C = {o, g, s, w}.

Ontology [Guarino, 2008] is a logical theory accounting for the intended meaning of a formal CPFR driven relationship, e.g. ontological commitment to D-E-C integration. The intended models of D-E-C integration using CPFR, which are a constraint by its ontological commitment. Ontology indirectly reflects CPFR and the underlying conceptualization by approximating these intended models. In figure 4 the intended models are restricted to formal definition of ontology. O is a prediction within limits of D-E-C integration.



<u>Figure 4 indicates the definition adapted from Guarino [2008]</u>

Regarding business intelligence (BI) there is a lag. According to van Beek [2010] the BI lag increases, because of increasing availability of data and reduction of time to evaluate stages. Decision making is supposed to be done in a very short time. Complexity and dynamics of the business environment increased during the postindustrial era. Liautaud [2004] mentioned that decisions are made by knowledge workers (e.g. architects, technical and financial engineers) and operators (e.g. foreman and craftsmen). However, currently managers (e.g. project managers and construction site managers) are collecting data in a traditional way and neglect the opportunities CN's offer.

Interpreting Guarino [2008] (table 6) the D-E-C integration points at the following: (1) Traditional business settings are no longer accepted. [Love et al. 2000; Caballero et al. 2001]; (2) All partners agree upon intent and rationale of design and engineering [Caballero et al. 2001]; (3) Web-based services related to SOA are open to all participants of a project; (4) Web-based services are required to integrate individual ERP environments (web parts) containing crucial documents [Worst, 2009] Following the language the domain and its admit table extensions can be defined (see figure 4) to D-E-C integration is a concept, which defines domain I structure <P,C>. A domain is collocated with projects (P). Collaboration (C) aligned to integration requires an object and specifications (o); guidelines (g); a synchronized process (s); and a workflow management system (s). So C = {o, g, s, w}.

The D-E-C integration model M is part of I equal to the domain of the integration language. Notation: M is partly a collection of I. The intended models denoted as building Object (O) structured according to <D,E,C> and the architecture's rationale (R) (I) K = <P,C>. Given the DEC integration it is possible to define the models M(I) and the intended models O given the CPFR concept <C,P> and the architecture's intent and rationale (R).

In particular "exception management" and "performance assessment" are crucial parts of CN's CPFR model. CPFR guidelines encompassed in the CN's agreement, assess integration of different but coherent disciplines. Given the organization of a project, partners are submitted to collaboration guidelines, a joint business plan, forecasting of user's needs, specific construction elements planning; logistics and task fulfillment, exception management and performance assessment. Table 7 indicates the process identifiers, qualifiers, functions and roles of partners and activities involved in the projects' supply chain.

Table 7: CPFR supporting D-E-C integration

Partners:	**Synchronized process:**	**Role in WFMS:**	**Object:**	**Activities:**
Investor/Buyer	Investment and contract partner of CPFR driven collaborative network.	Final approval.	Property investment.	Point of exploitation. Contracting collaborative network.
Leading consultant engineer.	Selection and identification of partners according to investors' and CPFR driven CN's guidelines.	First approval. Knowledge center. Delivery schedule.	One lump sum according to budget.	Planning delivery schedule, mobilization and controlling workflow management.
Architect	Design and identification of design according to investors' specification(s).	Feasibility, design and final design.	Materialization. Detailing design.	Identification of materialization. Identification of details.
Engineer(s)	Identification of design and engineering according to investors' specification(s) and construction method	Calculations. Construction method.	Construction elements split in construction tasks.	Identification and calculation of construction elements split in construction tasks.
Supplier(s)	Allocation of identified services, products and equipment.	Labor. Materials Equipment	Identified and classified products and services.	Allocation and application of labor, materials and services.

To establish a CN such as a virtual enterprise (an almost real business environment) adopting CPFR requires the fulfillment of:

- Ability to support ICT systems supporting collaborative networks (e.g. Web-EDI).
- Quality and solidity of organization, management and staff. Commitment to intentions and rationale of the investor and architect.
- Trust and Organization of Leadership, which means more leaders and less management. Responsibility and accountability are organized at the lowest level of the networks' organization. Commitment to guidelines of the CPFR-model

- Quality of construction capacity, and technical capacity, when looking at construction methods, engineering methods, and equipment.

Table 8: definition of ontology focused on D-E-C integration aligned to the CPFR model

Category:	Specification:
D-E-C Integration	CN's does not depend on particular D-E-C integration. Every partner could enter with own ERP and ICT environment.
Artificial Intelligence	Ontology refers to an engineering artifact. This artifact is constituted by CPFR to describe a certain reality. For instance virtual collaboration.
Relations	Explicit assumptions regarding the intended meaning of CPFR, which have the form of a logical theory. Intensions and rationale of architecture are the main determinants for trust and cooperation.
Intended meaning	Depends on CPFR plus the set of assumptions.
CN concepts regarding D-E-C integration.	I is a domain of projects' D-E-C integration C is a set of CPFR guidelines on P D-E-C integration is a concept, which defines domain I structure <P,C>.
Domain space	I is a set of maximal states of success considering CPFR. I is formulated according to table 7 and aligned to CN's.
Ontology [Guarino, 2008] (CN concepts) regarding integration of design, engineering and construction committed to CPFR, which is aligned to Collaborative Networks such as virtual enterprises.	Ontology is a logical theory accounting for the intended meaning of a formal CN, e.g. its ontological commitment to a particular CN concept. ***For instance a construction project.*** The intended models of collaboration using such a CN concept are constraint by its ontological commitment: ***CPFR guidelines.*** Ontology indirectly reflects this commitment (and the underlying conceptualization) by approximating these intended models. ***CPFR guidelines aligned to CN's.***

Conclusion: Ontology concerning D-E-C integration is crucial to cope with interfaces and CPFR adoption. Especially, when it concerns CN's aligned to a joint business plan and ICT guidelines. According to Guarino and Gruber [2008] this leads to ontology driven information systems. It is not an accidental type casting indicating the result of familiar activities, which are crucial when adopting interdisciplinary activities. In fact, it is an engineering artifact focused on managing interfaces in the context of D-E-C integration and structured by CPFR-model guidelines. An artifact using D-E-C integration to describe CN's given the reality of the construction industry's horizontal (value chain) and the construction industry's vertical (supply chain). The intended model represents the CN aligned to the CPFR principles shown in table 9.

Table 9 The intended CPFR-model determinants for construction projects

1. Strategy and planning focused on D-E-C Integration.	• Collaboration • Joint business plan per project
2. Forecasting	• End user's needs • Specific planning
3. Execution (Planning)	• Planning logistics and construction tasks • Planning construction tasks and segments
4. Performance and Analysis	• Execution Management • Performance Assessment

The construction industry has to deal with specific IT hardware configurations, information systems and development of CPFR aligned to web-based services (Web-EDI). According to Guarino [2008] building ontology's will help to shorten development time and building a CPFR web-based service open for CN's focused on D-E-C integration. Ontology enables reducing the number of interfaces and shorting run time of virtual project analysis. Although ontology is based on theory it will contribute to focused strategy and planning, forecasting, execution (planning) and performance assessment linked to exception management. CN's aligned to CPFR represent promising business paradigms to cope with the current turbulence on markets. Considering D-E-C integration, collaborative networks encompass opportunities like enlargement of capacity, cost effectiveness, avoidance of doubles, and cost reduction on interface management. Collaborative networks (CN's) adopting CPFR and aligned to D-E-C integration indicate total integrated transfers of total spatial solutions identified according to investors' specifications. They provide the best back-up of contracts encompassing offers meeting the "cost of ownership" standard e.g. LBC contracts. CN's aligned to CPFR modeling underpin synergy between "economies of scope" and "economies of scale". Collaboration means cooperation with identified partners. Fully deployed exception management supports performance assessment and contributes to sustainable and competitive collaborative networks.

CPFR indicates working according to strict collaborative guidelines and joint business plans. Supply chain management (SCM) is focused on forecasting "time to market" and "time to volume" set by guidelines to all partners involved in the construction process. In current practice often deployed as Continuous Process Monitoring. Strategy and planning of the CN's containing design, engineering and construction are clearly focused on the investor and user. Logistics and the building process are submitted to fulfillment of the contract.

Participation in CN's provide an opportunity to start a new economic life cycle. The adoption of Internet and alignment to web-based solutions indicate speed in work flow management and exchange of information. Participants such as architects, engineers, contractors, suppliers and subcontractors submitted to CPFR driven D-E-C integration have to accept new roles. In particular when ontology regarding a CN's domain and its interfaces aligned to CPFR guidelines is involved in construction supply chain management.

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Attachement (Source Worst 2009 «The Virtual Enterprise » published by MsM)

Model test concerning 125 W-E firms with a strong domestic market and web orientation.

Given the ECVI of 0.630 this model is stable, which indicates a perfect fit.

Table: The covariance relationship matrix of model

Constructs:		**Strategy**	**Culture**	**Technology**	**Performance**
Strategy	Nature of numbers:	1			
Culture	Correlation/Covariance coefficient	0.15	1		
Technology	Correlation/Covariance coefficient	0.07	0.642	1	
Performance	Correlation/Covariance coefficient	0.488	0.631	0.893	1

Strategy is determined by the investments in ICT enabling the adoption of web-based solutions. Strategy is very poorly correlated with Technology and Culture. Culture is based on gaining a strong domestic market position, and adoption of concurrent engineering. The correlation (table) between culture and technology is moderate. Performance is determined by familiarity with web-based solutions and the adoption of e-business. The correlation between performance and strategy is poor, which is moderate for the correlation between performance and culture. Technology is correlated with performance.

Model represents a strong domestic market position and a focus on e-business.

Fit indicators	**Model**	**Values**	**Fit**
N	108	> CN 134.25	Close to fit
Df	14		
Chi-square	23.358	Small	Excellent fit
Chi-square/Df	1,7	- < 2	Excellent fit
P	0.0547	> 0.05	Perfect fit
GFI	0.991	Close to perfect > 0.95	Perfect fit
AGFI	0.978	0.9 – 1	Good fit
PGFI	0.386	0 – 1 Sensitive to model size	Moderate fit
CFI	0.995	0.9 – 1 almost perfect	Perfect fit
NFI	0.988	0.9 – 1	Perfect fit
RMSEA	0.185	Poor > 0.1	Poor fit
RMR	0.124	Close to fit 0.1	Close to fit

Hypotheses testing of Model

Hypotheses	The chi-square indicates excellent fit. The GFI; AGFI; NFI, and PGFI indicate an almost perfect fit.
Hypothesis 1 General Contractors' and project related participants' business strategies are positively related to the e-business setting of virtual enterprises.	The hypothesis is true
Hypothesis 2 General Contractors' and project related participants' business culture is positively related to the e-business setting of virtual enterprises.	The hypothesis is true
Hypothesis 3 Contractors' and project related participants' adoption of ICT is positively related to the e-business setting of virtual enterprises.	The hypothesis is true

Conclusion

There is a gap between ICT strategy and the current options to arrive at entering virtual enterprises. However, there is distance between operational management and ICT management given the moderate correlation between culture and technology. Strategy is not correlated at all with culture and technology. The model indicates, that D-E-C participants do not opt for a strategy primarily focused on business models adopting web-based solutions. In fact, the power of business intelligence to arrive at virtual collaboration is completely ignored. Sharing information to control the interfaces between participants of the construction process to benefit from efficiency is not an issue.