Network-based business process management: embedding business logic in communications networks

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BIBLIOGRAPHIC DATA AND CLASSIFICATIONS		
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Abstract
Advanced Business Process Management (BPM) tools enable the decomposition of previously integrated and often ill-defined processes into re-usable process modules. These process modules can subsequently be distributed on the Internet over a variety of many different actors, each with their own specialization and economies-of-scale. The economic benefits of process specialization can be huge. However, how should such actors in a business network find, select, and control, the best partner for what part of the business process, in such a way that the best result is achieved? This particular management challenge requires more advanced techniques and tools in the enabling communications networks. An approach has been developed to embed business logic into the communications networks in order to optimize the allocation of business resources from a network point of view. Initial experimental results have been encouraging while at the same time demonstrating the need for more robust techniques in a future of massively distributed business processes.

Keywords
Business process management; Resource optimization; Active networks; Internet distributed process management; Embedded business logic, Payment systems, Programmable networks, Business protocols , Genetic algorithms

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Evolution of business process management (BPM) architectures

The new BPM systems make it possible to define process logic as an applications program and run this on different 'organisational environments' (that is, different computer systems and application programs, and different human interactions in the process flows). This approach has particular attractions to business and technologists:

- Processes can be properly defined in a runtime environment. Previous process modelling languages and tools often resulted in prescriptive recipes, were difficult, time-consuming and costly to implement. Now we can define and build small process modules, which can be templates in an organisational library, can be integrated within a complete process, plug-and-play in different environments, can be re-used, easily changed, and continually improved.

- Processes can be improved gradually: Existing processes are viewed as black-boxes, so the BPM logic defines a certain expected behavior, or norm, of present computer systems and human beings. Deviations from the expected norm are reported to the process management console while the BPM kernel event manager keeps track of all process events and flows.

- The behavior of processes can be governed by rule-engines so that process results can be changed very quickly and in a controlled way.

- Outsourcing of - elements of - business processes is made easy and manage-able as well as insourcing or service provisioning to business partners and others.

From business process to business network - Once process logic can be abstracted from its runtime environment it is possible to divide process modules over a number of different actors - defined as organizational entities - that are connected together via a communications infrastructure (see Figure 1)

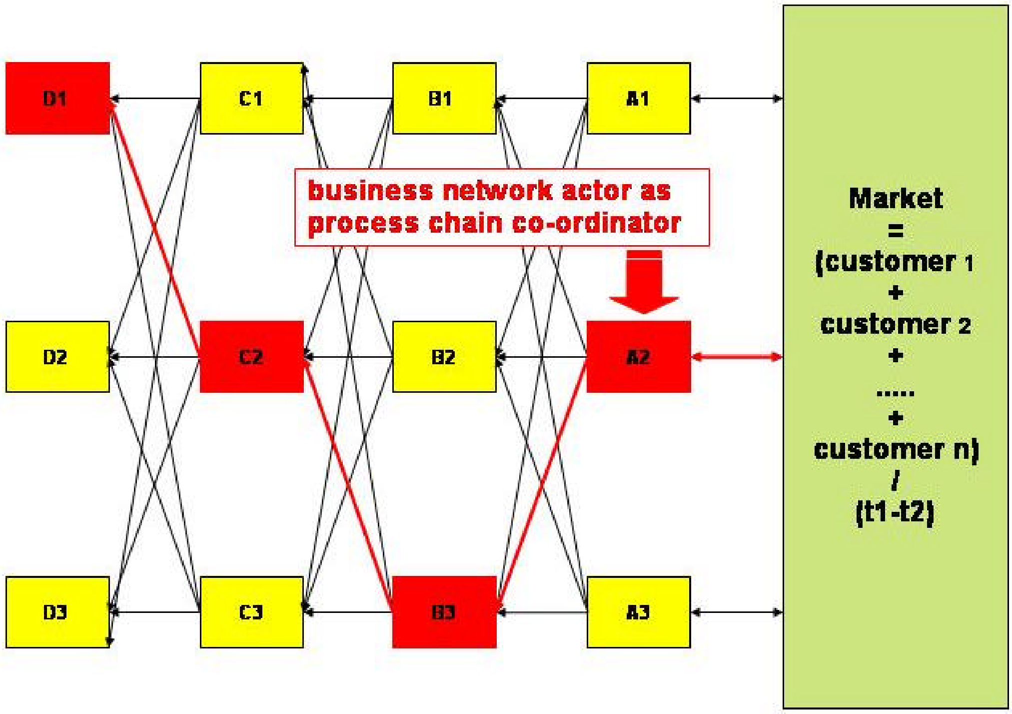

Figure 1: According to the Modular Network Design of business interactions, each actor pledges process modules (defined as service elements and production elements) that can be linked together to satisfy a defined customer order [1]

Organizations are depicted as nodes linked together in a business network: Each node can act to find other network partners and make business relationships: They connect parts, or 'modules' of their business processes together in order to create a more optimal result. Each actor in a business network will aim to find, select, and control the 'best' path through the business network: In this context 'best' is defined as the constrained optimization of resource utilization versus resource revenues in accordance with each actor's objectives. This can be called the actor's business logic. The advantages of process-specialization, e.g. by way of economies-of-scale, can be huge. However, the more business processes are defragmented into modular building blocks and distributed across different networks, the more process co-ordination will be required. This raises particular problems such as:

- the costs and managerial issues of many different computer and communications environments hindering fast monitoring of many different process events;

- the willingness of network actors to work together and exchange potentially sensitive information.

Generally, one of the major stumbling blocks to swift process co-ordination is the distribution of business and process logic over actors at the outside of the network. The business problem of path finding and resource allocation is also very similar to the issues surrounding naming/ addressing/ routing and capacity utilization in traditional communications network design and management.

This paper endeavours a novel approach to embedding business logic into the control layers of communications networks.

Evolution of communication architectures :

Some elements of this evolution , relevant to business process management , are highlighted for their potential in that area , with the potential highlighted at the end of each Sub-section .

Transport and signalling networks

What has been little realized outside technical circles within communications equipment suppliers or communication service suppliers , is that historically voice and data flows have obeyed two underlying design principles :

a) the separation of transport and content (voice, data) , although specific protocols and quality of service can regulate properties of the flows based on the application requirements ;today this extends to the regulatory definition of backbone network operators and access network operators on one hand, and content providers on the other hand
b) the separation of the transport networks from the control networks , which allow to set-up , manage, close and record the characteristics of connections or communication sessions ; such control networks are often, for availability and security reasons physically separate from the transport networks , and execute control functions in a connection based or connection less

way (SS7 and its equivalent for ATM networks in the first case , TCP in the second case, and SCTP as an intermediate solution) [1]

However , because obviously a control network is required to run and get revenue from a transport network , the ownership of the two was traditionally the same ,and thus the suppliers were traditionally supplying integrated transport and control networks with management thereof .Operators could embed via application-specific programming of the upper SS7 stack layers (MTP-3) , so called "intelligent network" or "computational intelligence " functionality , such as call admission control, mobile agents, etc ...(see e.g. [2]).

From the business process management point of view, the interest is not on the transport networks, but on the capabilities offered by the signalling/control networks .Admittedly , SS7 ,SCTP management exclusively by the operators gave them too much power in process management.

<u>Open signalling and adaptive networks</u>

From a technical and research perspective , things have changed with standards such as the IEEE P1520 standards [3] for interfaces to communication networks , as well as so called adaptive networks .Both define interfaces such that a user , e.g. the economic agent initiating a transaction , can determine the controls applicable to his own communication needs (connection, session , flow) ,and choose between transport networks or their dynamic configurations

Open signalling is implemented via standardized and publicly specified programming interfaces to networks .These interfaces rely on design architecture paradigms, which separate in the networks the control from the forwarding [4]. These paradigms also have interfaces to the network (software/hardware plug-ins) which are publicly documented and maintained, so that interface tool vendors can offer end users the ability to program the features matching their service demand profile directly into the network without having to let the operator provision it. Most such tools have to rely on distributed programming environments (DPE) and can be made easier and portable e.g. with Java, or C#,and CORBA (see e.g. URL for Mobiware). Such concepts are embodied most significantly in the IEEE Standard P1520 ([3] and URL IEEE P1520) , as supported e.g. by Bell Atlantic, France Telecom, Hitachi, KRDL, NEC, Nortel, xBind,etc .. with open interfaces towards IP and ATM based networks and services. The lack of commercial implementations on a wider scale hinges on lack of regulatory and legal frameworks for such functionalities , plus of course legacy and migration issues .

From the moment the P1520 (or similar) compliant service creation environments contain tariff tables linked to features of the QoS resource, router/switch management, resource processing, and IP packet filtering, then a suitable tariffing protocol between user and operator can allow for the automatic agreement on the tariffs and the automatic provisioning thereof. In such a solution, the billing work is essentially decentralized to the user, with full information access to the operator as part of the tariffing protocols.

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[1] The Stream Control Transmission protocol SCTP allows companies to exchange signalling information between switching systems using IP

From the business process management point of view, it should be possible to extend the IEEE P1520 programmable interfaces to networks , with corresponding programming model and binding mechanisms , to business logics and not just tariffs or quality of service .

Active networks :

The approach described above is especially appropriate for services implemented statically, usually of transactional nature, based on servers. Active networks cater to cases when the packet processing is distributed and performed by the routers along the path (or tree) to a destination . Obviously, the address of the nearest active node could be obtained by general procedures such as DHCP protocol. But it seems that the explicit addressing of routers and relaying between active nodes does not match the dynamic nature of the structure of an IP backbone. Moreover, it would not work with native multicast packets where a tree of processor nodes is implied. Last but not least, it is important that active processing can operate on regular packets (packets not to be processed by active entities). Therefore, an important requirement for the effective deployment of network-based services seems to be agent location transparency or, in other words, active node location transparency [5] , also tightly linked to mobile agent technology. This means that senders at active nodes expecting special processing to their packets by the network simply address the packets to their destination, and routers recognize them as special packets and process them according to a given code.

In this code may reside the label or tag which the individual tariff represents and which would be tied to the active node at which such tariffs are executed. The propagation of the tariff labels can be either the node hierarchy control or via additional fields in the routing tables. The advantage of this approach is that intelligent processing within the network can adapt the flow to the specific needs and tariffs of a sub-tree of receivers and prevent forwarding packets that will never reach its destination due to bottlenecks downstream or that will not be profitable in the playback. In this case, if active node location transparency is enabled, each party can multicast its traffic unaware of which network nodes in the distribution tree will adapt the flow.

From the point of view of business process management , active networks enable the capability to identify ,select and manage a set of economic agents involved in some of these processes ,and to manage their links .

Hot billing and pre-paid services

The usage and customer bases of wireless networks (public or WLAN) have opened up for another undetected change – Whereas traditionally subscription based fixed or mobile voice and data services rely on the delayed payment to the operator , via payment intermediaries , of the subscription , plus traffic (or bundles thereof) ,the need to check the outstanding balance prior and during a call against the credit balance of a pre-paid non-subscription customer , have shifted the ultimate solvency testing of the end user away from the payment intermediary over to the mobile operator and it's associated rating systems . Communications equipment providers have thus engineered interface and control systems which link directly the control network (which establishes the connection or session) with the customer care system (which checks on prepaid balances) ,all this in real time . What this means , is that from being traditionally trusted with the collection , aggregation , and solvency checks of the end user , the payment intermediary has only the collection task left . This turns the mobile operators into de facto deposit banks .As to the end user authentification , it is still split and essentially done twice in different ways , because of different processes for authentification on the communications service provisioning side of the operator (typically AAA servers) ,and for the payee authentification of the payment intermediary (typically a financial collection system with account identification and authentification) .

From the point of view of business process management , hot billing illustrates alltogether the ability of non-payment agents to take on financial deposits management, and even to extend this to other services , while managing the communication networks at the same time . Pre-paid services also illustrate the ability in mobile networks to activate and monitor service level agreements between parties in real time .

Embedding the business logics into the communication networks

<u>A communications-enabled business architecture</u>

Figure 2 shows how communication networks can provide a basic business architecture, with :
-a transport and capacity level , which is a technical agent chosen by the next level up
-a business and control level at which an economic agent determines his business logic around the information, transport and services he needs, to select and control the transport level ; this level interfaces with enterprise internal systems and information
-a verification and risk control level , where business logic vets and activates the control level
The technical nodes and business logics or protocols ,as well as the interfaces supporting this are defined and discussed below .

<u>Combination of network control logic with business logics/processes : the proposition</u>

Based on the above , we propose here ,and *formulated here first in business terms* , to embed the business logics and processes of each economic agent into the Business and control level of that Economic agent's control Node in the communications networks at the edges (see Figure 2) .

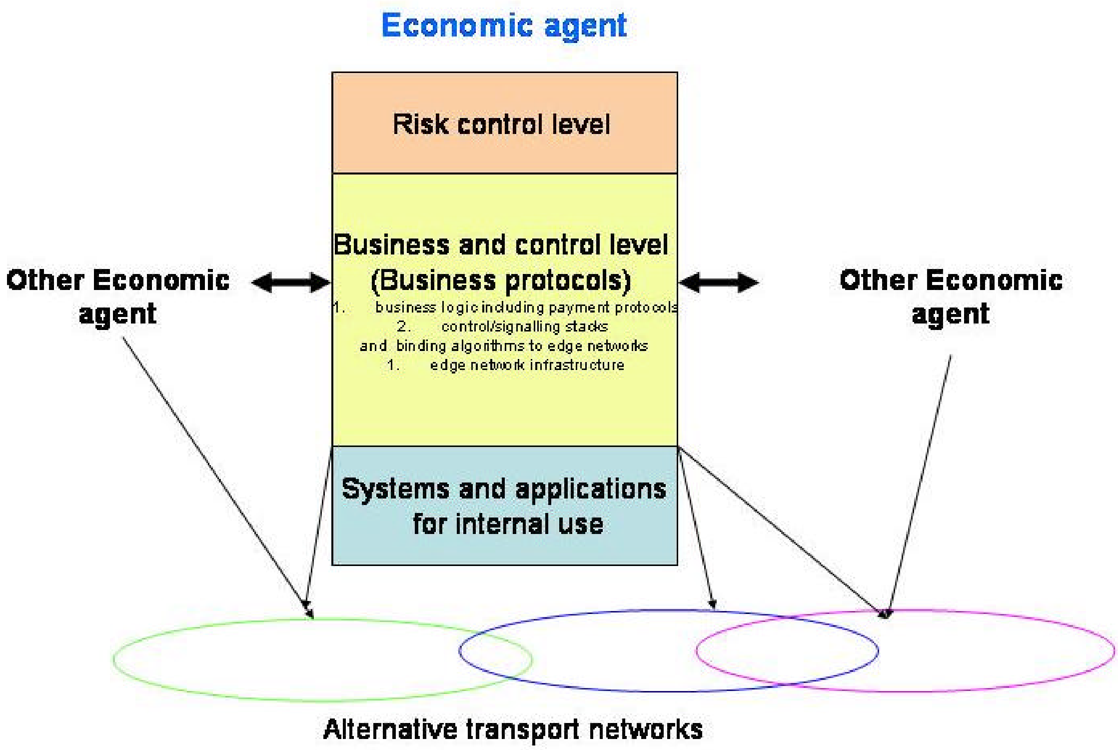

Figure 2 : Economic agent which interacts with other economic agents without general trade and payment intermediaries ; this agent has imported into its communications and computer systems the network control functions , and merged these with his own business logic and processes (trade, payment, ERP, etc ...)

Said in other words ,but *now formulated from a communications point of view*, each economic agent would install the interfaces and control software of communication networks ,and combine these with his own business logics and processes on both the trade and payment sides .

This is of course only possible, in terms of genericity and availability of the corresponding software , for those elements of the network control, trade processes and payment processes, which are best practices in each case – This implies of course that only specialized trade or payment intermediaries which have proprietary interfaces and processes , will co-exist with the economic agents initiating transactions , as the bulk of standardized processes will bypass them .

Transport networks and the network controls for these are unaffected, except that binding interfaces or active network features resident at the economic agent's premises would interface with them .

Figure 2 also highlights that , whereas all economic agents have engineered a possible choice of transports to support their needs at transport level ,some of these may be shared between economic agents who interact .This is obviously the case both for communication carriers , ISP's as well as transport/logistics networks . However , the economic agent who initiates the transaction or business may ,from his own business and control level, retain some control over such transport level resources .

Business control protocols : definition

We define here as "business control protocols , those procedures formalized in suitable standards (XML and UML) , which enable the execution of a business process (including the communications control) ,with enabling/disabling mechanisms by the risk control level ,and which are transport independent .

Main advantages and disadvantages

- *Advantages*

Some of the main advantages of this three-layer architecture are:

Complexity in the setup of business logics: For large volume transactions supported by common practice processes ,the complexity is reduced by industry practice (eventually standardized) business control protocols ,and by remote upgrades to these –Furthermore , the search for economic agent partners can be automated by auctioning tools [6] ,and can be faster modified , subject to risk controls and quality audits.

Cost and risks due to duplication of computing infrastructures:This is a major benefit in that the economic agent himself does not have to duplicate infrastructures/computing environments (for earlier separate corporate function) ,and does not have to carry part of the costs of the communications operators and of the computing infrastructures of the trading or payment intermediaries

Time and flexibility : This is the most important advantage, in that the economic agent alone determines when, to which extent and according to which policies , to change the business logics and processes .Furthermore , there is no need in managing conversions between systems or processes .

- *Disadvantages*

In terms of disadvantages , the following present a risk :

- Until the software and communications software industry deliver solutions with standardization ,some economic agents may have difficulties recruiting multidisciplinary resources to architect and implement business control protocols

- There is a risk that either the trading intermediaries, the payment intermediaries , or groups of economic agents themselves, will try to fragment the market by inconsistent standards and processes , and delay simplifying regulatory frameworks
- Resource utilization in terms of business flows on one hand ,and networks on the other hand, may not be optimal nor always scalable ; but what is aimed for is efficiency and resilience in the combination of the two at business process level

As to further enablers and limiting factors to this approach, we refer to Isenberg [7] , who points out that pushing network intelligence out to its edges is causing the communications industry to fail , whereas allowing the economic agents to unite their business models and communications needs will generate more demand for content-neutral transport .

Examples of business control protocols

Implementation architectures from the information technology point of view

Whereas the traditional BPM infrastructures were clearly distributed and heterogeneous , with some common trusted and standardized elements , they could be supported by such neutral architectures as CORBA with Object Request brokers and Web Services between the economic agents , each of them adding his own applications .
However , when business logics and processes are embedded into the communication networks , high demands must be put on the concurrent specification of the functionality both at application level (at least per domain) ,and for the communications , besides the needed portability of implementation instances .These are precisely the concerns which OMG's Model Driven architecture (MDA) addresses (URL OMG) , with not only CORBA objects , but also UML 2.0 specifications (especially of the communication services) , XML data structures and BPML [8] . Therefore we conjecture that MDA offers a good starting point for the specification , implementation and management of business architectures for which the business processes are embedded into the networks.

Example of a business control protocol : SNMP payments
A simple example is the combination of the SNMP Simple Network management protocol with payment and authorization. Such a business control protocol embodies the control of the transaction process by the economic agent without financial proxies.The list below details the steps between client and server (see also Figure 3):

</TCP Connection establishment
/Ready for mail
/HELO client name
/Server name
/Verify client name in (internal) data base

/Issue certificate
/Payment from sender's name
/OK
/Rcpt to recipient's name
/Select transaction type/
{Risk control rules to validate attributes of the protocol execution}
/Server fulfills payment
/Destination closing
/TCP cleared>

In this protocol, here much simplified , the SMTP Data field is empty , as this business control protocol just describes a process supported by the economic agent .

<u>Another example: real time SLA's for Mobile Internet</u>
Another example of business control protocols are real time SLA's between mobile operators and ISP's or content owners .The Rotterdam School of management is collaborating with the Open Group's QoS taskforce , and works in particular with the set of business processes whereby a mobile operator can in quasi-real time (on behalf of the end user issuing the request) authenticate and set up a service level agreement "on the fly" with an ISP (or content owner) which whom he has no relation sofar , just because of a mobile Internet request initiated spontaneously by an end user at that point of time [9] .

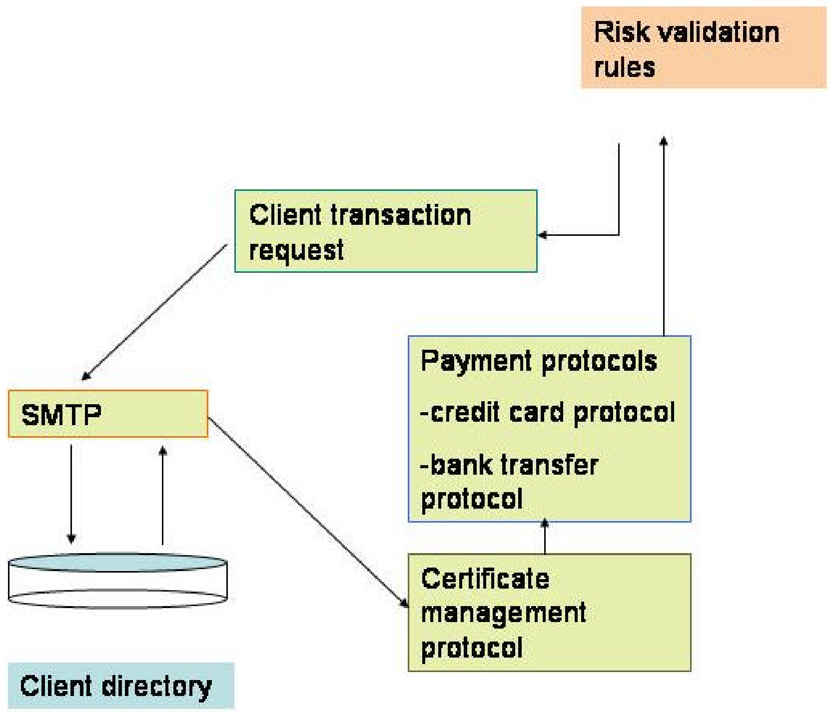

Figure 3 : Example of a business control protocol (parts in green , interacting with internal system in grey and risk control level in brown) enabling a payment process in combination with the SMTP network control . This Figure does not give the detailed flow of interactions between parties ,but only aggregates thereof

Future developments of integrated business and communications control logic

This paper investigates a novel way to embed business logic into the control layers of communications networks at the edges of the backbones . This is motivated e.g. by initial encouraging work at the Rotterdam School of Management in the field of logistics [9] , which shows that process modularization requires formalized languages as well as much faster exchange of process messages in order to result in improved logistical flows. This necessitates more business logic driven directly from the communications networks.

Also , as process events can be linked very quickly, and economic agents may recompose themselves and/or their functions , the dynamic resource optimization across many economic agents will be increasingly complicated. We suggest that some genetic and bio-informatics algorithms are useful to realize the corresponding adaptation selection and recalculations of the business logic embedded at the communications level [11]. A genetic algorithm is computationally modelled according to some processes of natural evolution such as mutation and cross-over. This means that , assuming a fitness index to be linked to the overall resource use , a better-fit process would have a higher attraction from the network actors than less-fit processes - which would be singled out. Mutation randomly changes process logic or business rules; crossover randomly chooses 'parent processes' and swaps some characteristics between the processes. Stopping rules can be applied to calculate Pareto or Stackelberg equilibria [12].

Finally , such an approach opens the way technically to individualized communications tariffs and process costs or each agent , with settlement not only by operators or financial institutions [13] .

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