A Transaction-oriented architecture for enterprise systems

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A Transaction-Oriented Architecture for Enterprise Systems

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ABSTRACT

Many enterprises risk business transactions based on information systems that are incomplete or misleading, given that 80-85% of all corporate information remains outside of their processing scope. It highlights that the bulk of information is too unstructured for these systems to process, but must be taken into account if those systems are to provide effective support. Computer technology nonetheless continues to become more and more predominant, illustrated by SAP A.G. recognising that 65-70% of the world's transactions are run using their technology. Using SAP as an illustrative case study, and by bringing in the benefits of technologies such as Service-Oriented Architecture (SOA), Business Process Management (BPM), Enterprise Architecture Frameworks (EA) and Conceptual Structures, a practical roadmap is identified to a Transaction-Oriented Architecture (TOA) that is predicated on the Transaction Concept. This concept builds upon the Resources-Events-Agents (REA) modelling pattern that is close to business reality. Enterprise systems can thus better incorporate that missing 80-85% of hitherto too-unstructured information thereby allowing enterprise systems vendors such as SAP, their competitors, customers, suppliers and partners to do an ever better job with the world's transactions.

Keywords: *Business Process Management/Modelling (BPM), Combining and Unifying Business Intelligence with Semantic Technologies (CUBIST), Conceptual Structures, Enterprise Architecture (EA), Process-Oriented Architecture (POA), Resources-Events-Agents (REA), SAP A.G., Semiotic Ladder, Service-Oriented Architecture (SOA), Transaction-Oriented Architecture (TOA), Transaction Concept (TC)*

INTRODUCTION

Many enterprises risk business transactions based on information systems that are incomplete or misleading, augmenting the claim that 80-85% of all corporate information remains outside of the processing scope of such systems (Seidman, 2004; Polovina & Andrews, 2011). Essentially, the bulk of information is too unstructured for these systems to process, but must be taken into account if those systems are to provide effective support. However, as these enterprise systems become more and more predominant the issue becomes increasingly acute. Indeed SAP as a significant vendor of enterprise systems have noted that 65-70% of the

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world's transactions involve SAP systems; thus to maintain this share and the responsibilities it brings they "have to do a good job" (Forbes LLC, 2011). Enterprise systems are being expected to align more and more with the essence of the enterprise and through the productivity of computers lever this knowledge about itself and become more successful.

APPROACHES

Accordingly there has been a substantial push to Service-Oriented Architecture (SOA) and an eco-system that in SAP's case is epitomised by the Enterprise Services Workplace (ESW) (SAP A.G., 2012). Allied to these approaches is the integration of Business Intelligence (BI), particularly in handing the proliferation of data (Economist, 2010) and in conjunction with novel database querying tools such as Hadoop Impala (Cloudera, Inc., 2013). In SAP's case, there has been the emergence of the *H*igh-Performance *An*alytic *A*ppliance (SAP HANA) architecture (Word, 2013; SAP A.G., 2013). A continuation of BI is to apply semantic technologies that structure unstructured data. These information extraction technologies take knowledge management a stage further by discovering knowledge hitherto hidden in that data, thereby capturing much more of that elusive 80-85% of corporate information. The Combining and Unifying BI with Semantic Technologies project (CUBIST) is an exemplar of extracting meaning from structured and unstructured data to discover knowledge (CUBIST project, 2013).

Service-Oriented Architecture (SOA)

SOA recognises the limitations of existing enterprise applications that have been built along the lines of large functional silos such as Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Supplier Relationship Management (SRM), Financials, or even for specific industries (the so-called 'verticals' applications) such as Oil and Gas, Healthcare, Banking, Telecommunications or Public Sector.

Whilst all these applications reflect actual applications rather than a technology seeking an application (e.g. Database Systems), the semantics (or 'meaning') of business activity are at a much lower granular level than those applications imply. Rather, like object-oriented approaches, business activity is made up of a number of service components, namely 'business objects' that can be orchestrated into business processes according to the business requirements. With intermediate levels of orchestration of these objects into process components that in turn can become part of deployment units, enterprise applications are individually configured in a way that better aligns with the given business need. Standardisation is achieved at the component rather than the application level, thus taking advantage of reusability. Agility is achieved by re-orchestrating or enabling new components in direct response to changing business needs. To allow flexible orchestration and re-orchestration, the service interfaces of each business object are also defined according to a standardised governance process. Even the data of each business object are built according to Global Data Types (GDTs).

All in all, SOA provides an operational architecture that makes component based software development become realistic for enterprise systems. SOA development distinguishes itself from object-orientation to the extent that each component is centred on providing a *service*; in our case a composite element of business semantics that *adds value* to the enterprise application. The technical nature of each component is encapsulated by its business meaning, thus can be directly applied by Business Process Management (BPM) and its associated Business Process Modelling (whose acronym is also BPM) to orchestrate business processes.

Enterprise Services Workplace (ESW)

To operationalise SOA (i.e. to make it possible) many vendors and their partners and customers have recognised that the definition and service interfaces of the many resulting business objects cannot be conceptualised, developed and implemented by the vendors alone. Rather it requires a collaborative eco-system that in SAP's case is epitomised by the Enterprise Services Workplace (ESW). As such, vendors, partners, customers and anyone essentially can contribute to the construction of the SOA. Many components can draw on the vendors established expertise, as a 'de-assembly' of their existing enterprise applications or the creation of 'enterprise services'. Some components may only consist of their interfaces defined in WSDL, at least describing to this extent the business semantics of that component using the Web Services recommendations that SOA is conventionally based upon.

Business Intelligence

In SOA, business objects are conceptualised through the collaboration of the participants as SAP describes in an 'ecosystem' (SAP A.G., 2013). This 'top down' process might be integrated with 'bottom up' knowledge discovery from the data itself. The patterns of the behaviour of the data (e.g. sales figures for a given set of customers in a product-market) is interpreted through a query of that data i.e. Business Intelligence (BI). BI is helped by novel database querying technologies that cut across traditional data divides such as Hadoop Impala as referred to earlier (Cloudera, Inc., 2013). Along with such developments there has been an overall bringing closer together of SOA and BI, with the latter's in-memory analytics. The former (SOA) as enterprise applications has traditionally been structured according to online transaction processing (OLTP) whereas the latter (BI) relies on online analytical processing (OLAP), resulting in an overhead of de-normalising data from the former and creating data cubes to permit the latter to take place. By enabling this to take place in computer memory rather than disk access, information can be requested and responded to instantaneously as SAP states in "real real time" through its High-Performance Analytic Appliance (HANA) architecture referred to earlier. HANA will go beyond the simple placing of OLTP and OLAP together in-memory into a much more integrated architecture (Word, 2013). HANA has been compared to Impala as complimentary technologies for analytics on 'big data', a term that refers to the proliferation-of-data remark made earlier (MacDonald, 2013; Economist, 2010). HANA reflects SAP's now ongoing commitment to offer "innovation without disruption", thus capitalising on the benefits of disruptive technology without the heightened risks that such innovations bring (Christensen, 1997).

Semantic Technologies

To assist BI, semantic technologies such as those being investigated in CUBIST can extract the information from both structured and unstructured data. It enables more informed querying to take place as well as discover hitherto hidden meaning from the data. In CUBIST this is envisaged through an integration of Semantic Web technology through OWLIM with Formal Concept Analysis (FCA), and tested on data use cases in i) biology, ii) space telemetry and iii) job market analysis (CUBIST project, 2013; Ganter, Stumme, & Wille, 2005; Ontotext AD, 2013). FCA is an automated technique that identifies the conceptual structures among data sets. FCA is a formal method as it mathematically discovers the concepts from the patterns in the data according to the objects and attributes that make up that data. Moreover, these formal concepts are related to other formal concepts in a lattice structure (known as Galois connections). Through these interrelated formal concepts, FCA thus has the potential to complement the cognitive conceptualisation of business objects and service interfaces with those that are machine-generated from data.

Automation in BPM

From the above approaches, we can begin to appreciate how enterprise systems will more expressively align with the enterprises they are meant to support and enhance. As these approaches become more and more established, more and more enterprises will have systems that at last can record the business transactions that embody the purpose of the enterprise. As the approaches become established technologies, business will begin to take them for granted. This may be the height of enterprise systems, but it is possible to foresee that it will in turn offer new opportunities for enterprises. One evident possibility is introducing computer automation into the hitherto human-centric businesses process orchestration itself though software agents as described shortly. This potential development could be built upon the existing developments in the use of enterprise social media to facilitate collaborative BPM. An example of such an existing development is SAP StreamWork, which is now a part of Jam (SuccessFactors, 2013).

Social Media and BPM

Enterprise social media can usefully be applied to BPM. The StreamWork project worked with partners well-known in this field such as Google, Novell, Evernote, Scribd, and Box. It took the general collaborative features found in social media technologies and augments them with BPM tools such as Business Process Modelling Notation (BPMN) (Object Management Group, 2013). It thus as described earlier brings SOA into the suite of tools available in social media. Let us therefore begin to outline the extent of automation in the future stages of these tools' development.

ADDING SOFTWARE AGENTS, CONCEPTUAL STRUCTURES

The presence of BPM tools in social media has thereby enabled collaborative computer-mediated BPM to take place, thus opening the way for more technologies to be integrated in this environment. One pertinent route is the incorporation of software agents as partners in the collaborative process. These agents would not only bring the productivity of computers as counterpart to the creativity of the human experts in the BPM process, these software agents can search and appropriate the many resources of the Web, Intranets and Internet and distil their findings to the benefit of the human collaborators.

Conceptual Structures (CS) might also be brought into BPM. Notably, CS is about technologies that "harmonises the creativity of humans with the productivity of computers. CS recognise that organisations work with concepts; machines like structures". CS "advances the theory and practice in connecting the user's conceptual approach to problem solving with the formal structures that computer applications need to bring their productivity to bear in solving these problems". CS enables "Knowledge Architectures [that] give rise to smart applications that allow enterprises to share meaning across their interconnected computing resources and to realize transactions that would otherwise remain as lost business opportunities." (Priss, Polovina, & Hill, 2007; Polovina, 2007; Polovina, Hill, & Akhgar, 2009).

CONCEPTUAL AND ARCHITECTURAL FRAMEWORKS

Although there are expressive CS environments such as Conceptual Graphs (CGs) and Formal Concept Analysis (FCA), ISO Common Logic, as well as Semantic Web technologies based on such as Description Logics (DL) or Datalog, the agents would need a frame of reference in order to fulfil their role as knowledgeable providers (Delugach, 2007; Baader, Calvanese, McGuinness, Nardi, & Patel-Schneider, 2010; de Moor, Gottlob, Furche, & Sellers, 2010).

For this purpose the human participants may refer to an Enterprise Architecture Framework (EAF) such as TOGAF, SAP's EAF (based on TOGAF), or Zachman (The Open Group, 2013; Zachman International, Inc., 2012). Or Principles like Moore's Core-Context (Moore, 2002). Working with concepts, the human experts (e.g. Enterprise or Solution Architects, or Business Process Experts) would appreciate that "all models are wrong, but some are useful" (Box & Draper, 1987, p. 424). Put simply, they would see them as frameworks that offer solutions that recognise "It is better to be vaguely right than exactly wrong" (Read, 1898, p. 272). There thus remains an element of human intuition that, as evidenced in experiences such as those from Artificial Intelligence, cannot easily be computer programmed thus also remain outside of enterprise systems. The software agents therefore have to overcome to some useful degree their computer-based limitations to be effective participants.

Multi-Agent Systems (MAS) offer one promising route forward. One avenue of research has explored how they might be deployed in enterprise systems through the Resources-Events-Agents (REA) modelling pattern that is closer to business reality (Vymětal & Scheller, 2012). Other work has taken on the REA approach and, using CGs, provided an early requirements capture specification, known as *Tr*ansaction *A*gent *M*odelling (TrAM) (Hill, Polovina, & Shadija, 2006). A variant of this work has been the Transaction Graph, using CGs to apply TrAM in Enterprise Architecture projects (Launders, 2012). This work augments Enterprise Architecture Frameworks so that semantic enterprise applications can be built. Some of this work is illustrated by a Transaction Graph (in CGs) and Transaction Lattice (in FCA) for a University case study is shown by Figure 1 (Andrews & Polovina, 2011). Other work describes a Financial Trading case study as well as for health, mobile services, manufacturing and in learning (Polovina & Andrews, 2011; Polovina & Hill, 2009). One study presents a case for ISO Common Logic in realising an Open Semantic Enterprise Architecture (Bridges, Schiffel, & Polovina, 2011).

THE TRANSACTION CONCEPT

The term 'transaction' appears in a number of the above works. They demonstrate 'Transaction' as a high-level declarative statement that identifies the enterprise itself rather than a number of lower-level transactions that support its business processes (or, in SAP's terms the transactions that make up its ERP and other systems). Rather, the Transaction is a concept that restates the enterprise's mission statement, but presenting it in a balanced way that shows what an enterprise is willing to sacrifice ('pay') to satisfy the desires in its mission statement. It captures the fact that enterprises do not always seek to maximise their profit in purely monetary ways. Even many outwardly profit-oriented enterprises present their mission statements in qualitative ways (e.g. quality of service, duty to all stakeholders, society, and reputation to name a few).

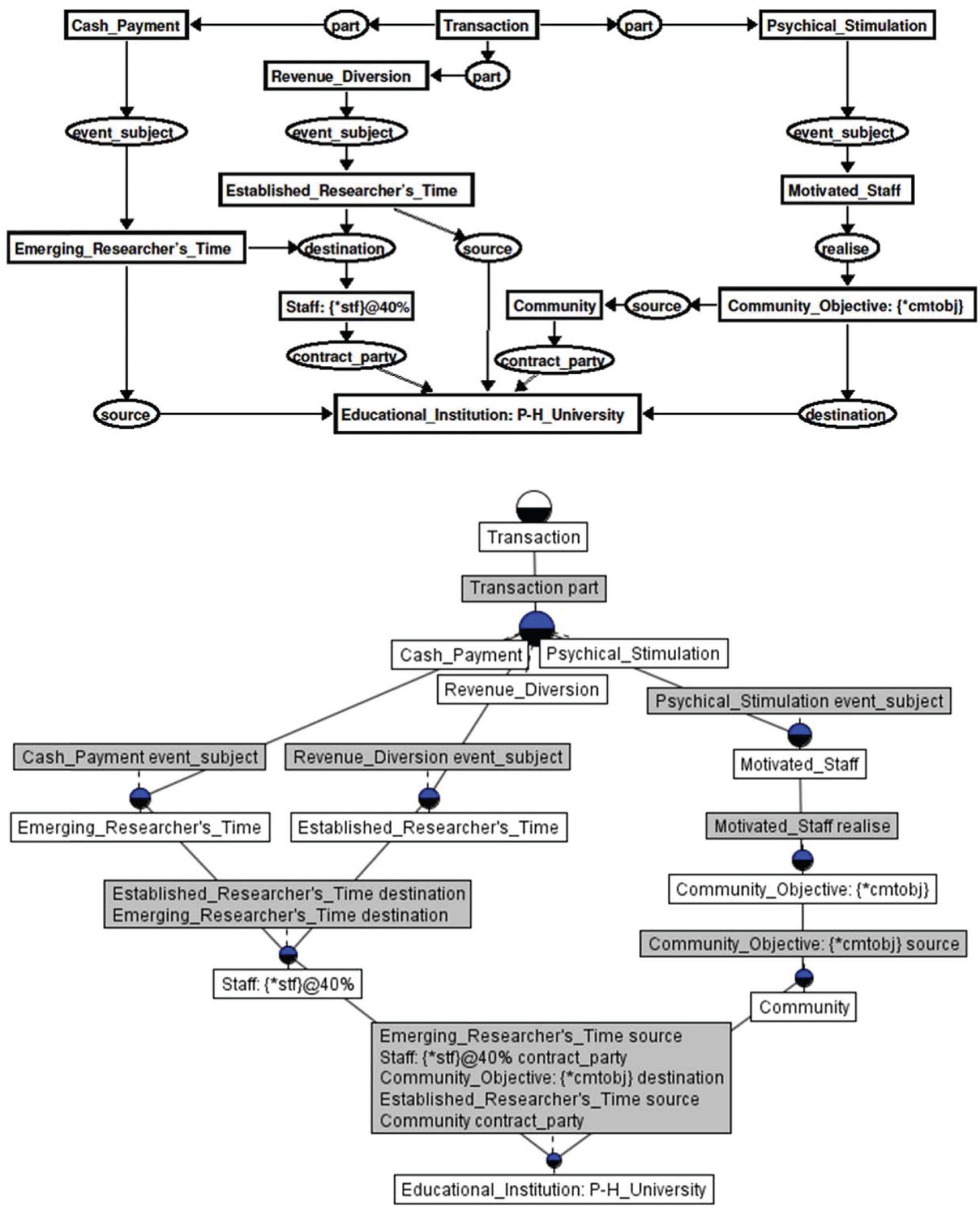
Whilst possibly confusing when we think of transactions, this is consistent with the concept of a transaction given by the dictionary definitions of this term (e.g. www.merriam-webster.com/dictionary/transaction). We may therefore make a distinction by using Transaction with an initial uppercase T as opposed to transaction beginning with a lowercase 't' (i.e. Transaction vs. transaction; the overarching strategic Transaction(s) that epitomises the very enterprise itself as opposed to the many day-to-day system level transactions). It may be viewed as roughly analogous to 'cloud' or 'kite' (or business-level) use cases vs. 'sea-level'/'fish-level' system use cases (Kench, 2009). To explicate the Transaction (note uppercase initial T), a Transaction Use Case Diagram (TUCD) exists (Launders, 2012).

Given that even the use of uppercase T vs. lowercase t as a device may still provide an inadequate level of distinction, and as supported by the foregoing discussion, the term Transaction Concept (TC) is given to mean Transaction.

THE SEMIOTIC LADDER

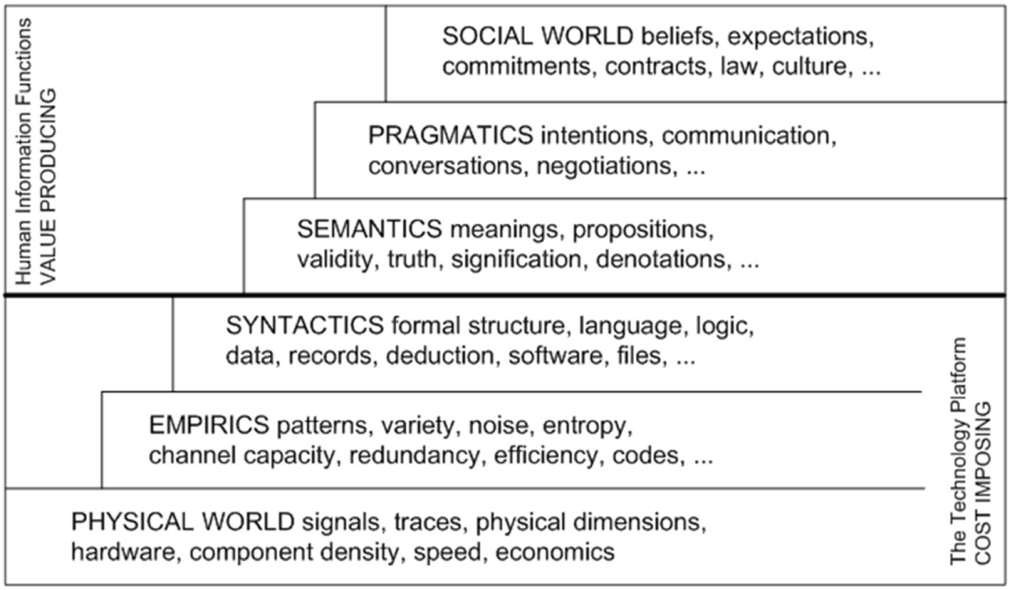
The dimensions of the TC can further be illustrated by the Semiotic Ladder (Stamper, 1996), Figure 2.

Figure 1. Transaction graph (top diagram), lattice (bottom diagram)



Essentially, the 'cost imposing' layers in this ladder structure illustrate the areas in which the productivity of computers ('the technology platform') benefit information (enterprise) systems much better than manual systems. It is where computers are much better than humans, hence the success of technologies such as data processing that nowadays we cannot imagine being without. The 'value producing' layers are where humans are better than computers. Classical experiences from Artificial Intelligence have shown how poorly computers perform

Figure 2. The semiotic ladder



in these areas, but more recent technologies such as knowledge management systems, and SOA/BPM with MAS as described can play a pertinent role.

Enterprise Architecture Frameworks are intended to capture the Enterprise holistically, in line with an Architect's remark when asked what Architects do i.e. "from a blank sheet of paper to the position of last nail in the wall". Essentially, these frameworks cover the whole range of the ladder. Transactions too are wide-ranging, from those supporting ACID (Atomicity, Consistency, Isolation, Durability) at the database level and the transactions in SAP systems, through to business transactions denoting an agreement between a buyer and a seller to exchange an asset for payment through to the TC itself. Accordingly, transactions (from little t to Big T) transcend the steps of the ladder, thereby Enterprise Architecture Frameworks.

Transactions describe why the enterprise exists. It explicates what the enterprise offers, what it desires in return, and the assessed risks in achieving these rewards. It gives the enterprise its sense of direction; consequently it can give enterprise systems the same direction, in line with the expectations of the semiotic ladder.

TRANSACTION-ORIENTED ARCHITECTURE (TOA)

A Transaction-Oriented Architecture (TOA) provides the framework by which an enterprise's business processes are orchestrated according to the TC (Transaction Concept). The TOA brings purpose and direction to SOA (Service-Oriented Architecture), further assisted by Process-Oriented Architecture (POA), which offers a reference architecture by which SOA can be orchestrated according to business processes, for example the way that Business Objects in the ESW (Enterprise Services Workplace) are orchestrated into new Process Components that can be added dynamically to the ESW. TOA culminates SOA and enterprise applications' productivity including SAP's to the height of the real, transactional world that enterprises operate.

Figure 3 illustrates TOA as the capstone of a pyramid. It shows how the ESW underpins SOA, which is additionally supported through the discovery of new Business Objects from BI knowledge discovery projects like CUBIST and the enhanced performance of Hadoop Impala and HANA as illustrations. SOA and POA are supported by social media and BPM, illustrated by SAP's StreamWork technology. MAS (Multi-Agent Systems) can help automate the orchestration of SOA and POA. These software agents may act as software partners to the human participants in simulating drafts of processes and interactively feed-back the extent to which they exemplify Moore's Core-Context Principles in a given POA project. Thus, like the Semantic Web, technology meaningfully enters the domain of the hitherto alien territory of human information functions in the semiotic ladder. The TOA uses the Transaction Graph and the Transaction Lattice, here for a Financial Trading case study (Launders, 2012). Given that the TC draws upon REA (Resource-Events-Agents) and TrAM (Transaction Agent Modelling), MAS becomes inherent in TOA too. Technology's usefulness is thus driven up the semiotic ladder referred to earlier in Figure 2. To assist understanding of the various building blocks used for TOA, Table 1 summarises some of already-described key acronyms in Figure 3.

CONCLUDING REMARKS

TOA offers a practical roadmap for the future development of SOA, BPM, BI, Social Media, MAS, Semantic Technologies and Conceptual Structures. It supports the development of Architectures for Enterprise Applications that ameliorate the 80-85% of corporate information that remains outside of the processing scope of existing enterprise systems. By supporting

Figure 3. The TOA

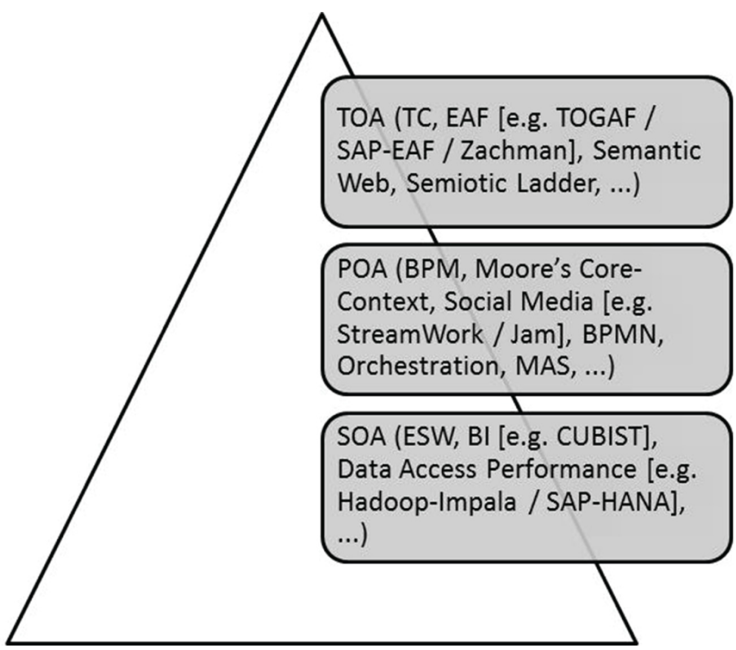


Table 1. Certain acronyms used to describe the building blocks in TOA

Acronym	Description
BI	Business Intelligence – the gathering, analysis and presentation of internal or external data to provide intelligence so that business decision-makers can make better informed decisions, given the data reflects the past, present and potential future state of the business' performance.
BPM	Business Process Management (/Modelling) – the management or modelling of the steps (activities) that make up a process that a business needs to undertake to achieve some desired outcome (e.g. Purchasing) in the most optimal and less risk way; given its business focus, the BPM activities provide the semantic (meaning) to which the SOA Components (Enterprise Services) can be mapped thereby defining their value-added service.
BPMN	Business Process Modelling and Notation – A BPM tool maintained by the Open Management Group (OMG) that provides a visual notation of the elements in a business process (e.g. activities) in a way that can be mapped to SOA Components (Enterprise Services).
EAF	Enterprise Architecture Framework – A frame of reference and underlying meta-model of the generic features of enterprises or industries, thus supporting their useful modelling by drawing from best practices and experiences; pertinent to these models is that their context considers the whole enterprise, from its business strategy to their day-to-day operation – "from concept to the last nail in the wall".
ESW	Enterprise Services Workplace – an SAP-maintained collaborative repository of SOA components (Enterprise Services) ranging from individual entities (Business Objects), business Process Components and accessible as Web Services, Integration Scenarios right through to Solution Maps for whole Industries (e.g. Oil and Gas, Healthcare, Banking, …) or whole Application areas such as ERP (Enterprise Resource Planning).
MAS	Multi-Agent Systems – Automated software agents that are 'smart' in that they can make intelligent choices based for example on their programmed beliefs, desires or intentions (BDI); with the TC as their framework they can help decide the transactions to engage with or not, and assembling (orchestrating) the business processes to fulfil those transactions.
POA	Process-Oriented Architecture – an approach that takes a business process centric view of the enterprise, thus providing a reference architecture for services and upon which the TOA (through the high-level TC) can be mapped to those actual services.
SOA	Service-Oriented Architecture – an approach that exposes meaningfully-sized components hitherto hidden inside large applications or new components, enabling access to their value-adding services in novel application reassemblies.
TC	Transaction Concept – The concept of a transaction that extends to the highest level (big 'T') transaction that defines the very nature of the enterprise itself rather than just its operational day-to-day (little 't') transactions; accordingly it is described as a Conceptual Structure at the logical level as the Transaction Graph in Conceptual Graphs (CGs) and the mathematical level as a Transaction Lattice through Formal Concept Analysis (FCA).

the expressivity of Enterprise Architecture Frameworks with the described technologies, technology – the productivity of computers – enters the human information functions in the semiotic ladder. Computer productivity is merged with human creativity, reflecting Moore's Core-Context principles that enterprises are distinguished from each other by the creativity of the human participants. SOA has become a reality. With associated developments in POA and the emerging Semantic and MAS Technologies, we can begin to envisage Conceptual Structures that better incorporate that missing 80-85% of hitherto too-unstructured information. And with the TC as its heart, allow enterprise systems vendors such as SAP, their customers, suppliers and partners to do an ever better job with the world's transactions.

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Simon Polovina engages in roles that draw upon his expertise in Enterprise Architecture and Conceptual Structures (CS). His interests include the use of Enterprise Systems that can also detect novel or unusual transactions that would otherwise remain as lost business opportunities or represent illicit business or criminal activity. He is currently a Principal Investigator for the prestigious European Commission 7th Framework Programme project CUBIST ("Combining and Unifying Business Intelligence with Semantic Technologies"), where he is applying CS and co-managing the project. CUBIST is centred on applying smart technologies (namely CS and the Semantic Web) to Business Intelligence. It is a €4m project funded under topic 4.3: Intelligent Information Management. He is the Enterprise Architect for CENTRIC (Centre of excellence in terrorism, resilience, intelligence & organised crime research) and a Reader in Business Computing at Sheffield Hallam University, UK.

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