Technical Brief

ALIGNING BUSINESS AND IT

THE PROCESS-DRIVEN ARCHITECTURE MODEL

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CONTENTS

ABSTRACT

Due to the fact that the corporate IT function is tightly coupled to enterprise processes and organization today's IT is driven by the same dynamics as the enterprise itself. Based on this observation a four-layer process-driven architecture (PDA) model is derived which explicitly addresses current business and IT issues alike. The applicability of the model is demonstrated on both the descriptive and the prescriptive level of a theory. Additionally, the level of abstraction employed establishes the PDA model as a suitable framework for addressing the alignment of business and IT.

KEYWORDS

Service-Oriented Architecture (SOA),
Business Process Management (BPM) Business Process Management Systems (BPMS), IT architecture, business and IT alignment, business–IT divide, semantic web, information management.

I. INTRODUCTION

Enterprise (IT) architects face an increasingly difficult (not to say: daunting) task: On one hand the very notion of "IT architecture" or "enterprise architecture" in itself constitutes a somewhat fuzzy concept which has almost as much to do with the structural properties of the enterprise IT landscape [1]–[3] as with a particular attitude, stance, or elevated observation point (*scil.* of the architect) in order to escape the dreaded *analysis paralysis* typical for reactive systems [4], [5] with an underlying fractal and self-similar order [6]–[8].

On the other hand it is evident that the success of today's enterprises (measured, e.g., in terms of revenue growth and profitability) considerably and directly depends on the inner workings and capabilities of their IT function. Moreover, information systems (IS) and IT infrastructure have evolved into an "IT fabric" [9] (also called "nervous system" [10], [11]) inextricably entangled and intertwined with the business processes and information processing activities it is supposed to support. Consequently, today's IT function is driven by the very same dynamics as the enterprise itself [12]. Due to this tight coupling IT

capabilities either embodied and enabled or prohibited and restricted by particular architectural choices to a very large degree determine current and future performance characteristics of modern enterprises. In other words: IT architecture – including at the very center the specific architecture model – has become a strategic asset for the whole organization.

This paper addresses this challenging role of IT architecture and proposes, on a business and IT managerial level, a new high-level architecture model explicitly recognizing current and future business and IT drivers alike.

We explicate our reasoning by first examining current issues and pressures in the business domain in section II (e.g., growing complexity and competition) and in the IT domain (section III) such as the negative impacts of the so-called distributed n-tier IT architectures common to the IT landscape of many (if not all) enterprises.

Based on these deliberations we propose and further describe a four-layer architectural model in section IV called the *Process-Driven Architecture (PDA) model*.

The viability of our PDA model is demonstrated in section V in forward-backward style: We first assume a descriptive stance and establish how the PDA model permits a thorough analysis of the *status quo* of typical corporate IT environments. Then we switch to a prescriptive mode and derive the issues which may be advanced by relying on our PDA model.

Even though no single and unanimously accepted definition of "architecture" (*scil.* of IT) exists we clearly observe a consensus on the common characteristics and adopt, for the purposes of this paper, the following definition [1]–[3], [12]–[14]:

"Architecture" comprises the set of significant decisions concerning the (high level) structure of all elements comprising the enterprise IT function including software elements, externally visible properties of the elements, and relationships amongst them.

II. BUSINESS DRIVERS

Today's enterprises with their (complicated) internal organizational structure and procedures are subject to an ever increasing level of external (environmental) pressure prompting for adequate internal responses (cf. Table I).

We do not want to focus on the underlying macroeconomic sources of these issues such as globalization [15] and digitization [16], [17] but rather concentrate on the necessary internal requirements and capabilities enterprises must possess or acquire in order to stay competitive (or even survive) today.

Take, for instance, mounting complexity where, contrary to popular belief, the solution does not lie in even higher (managerial) abstractions in order to deal and manage it or in an increase in ignorance, which is also a highly effective means of complexity reduction, but in providing even more information.

Within general systems theory [18], [19] and based on W. R. Ashby's discovery [20] this proposition is often paraphrased as *"Only variety can destroy variety"* in the sense that any totally effective controlling system (read: management) must be at least (!) as complex as the controlled system (read: the organization, the enterprise). We also want to stress that this is a mathematically provable law of nature and is not in any way connected to some "soft" facts concerning our human capabilities of information processing. Deplorably, within both general management and IT management this fact has been ignored for the last decades with only some exceptions [21], [22].

Albeit, given the hierarchical organization of most corporations and an ever mounting "information glut" and "information overload" [23] supplying more information revolves around the (new) notion of "information logistics": providing information at the right time, in the right quality, in the right form, at the right place, and at the "right" costs.

We also have to deconstruct another common misconception regarding the notion of "shareholder value". This, at least originally [24], had nothing directly (!) to do with the value of a company's shares but identified eight "value drivers" determining the (future) value of an enterprise by way of a dynamic cash-flow calculation [25], cf. Fig. 1.

TABLE I. BUSINESS DRIVERS

External Pressures	Internal Requirements
¬ increasing complexity	¬ more information
¬ rising competition	¬ increased flexibility
¬ mounting uncertainty	¬ need for speed and agility
¬ shareholder value	¬ focus on profitability

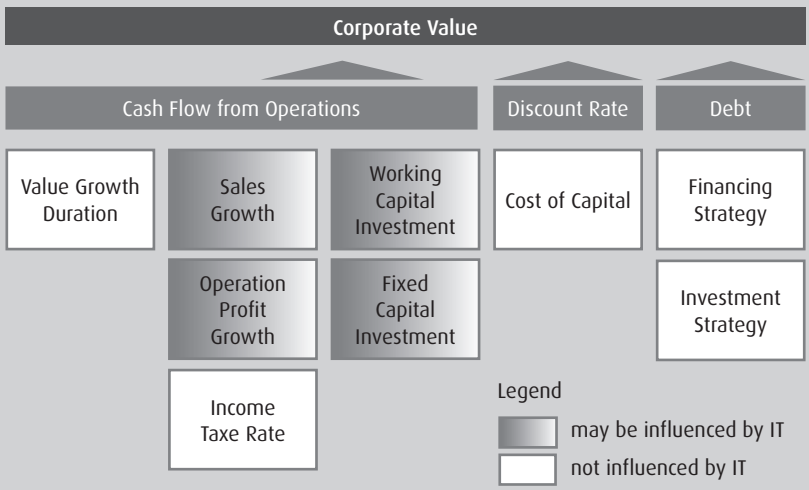


Fig 3: Drivers of Shareholder Value

It is worth noting that of these drivers only four can actually be influenced by the IT function at all (highlighted and inversed in Fig. 1).

III. IT DRIVERS

Commoditization and IT's (Near) Irrelevance

However, not only businesses in general but also the IT function in particular is subject to increasing scrutiny and pressure. In a landmark (and highly controversial) article, Harvard Business Review Editor Nicholas Carr articulated a somewhat drastic future of IT mounting the bold claim "IT doesn't matter" [26], [27].

He argued that standardization, comoditization, IT infrastructure build-out, and ubiquity of services have transformed both information systems and IT infrastructure into a competitive necessity. This entails different objectives for managing IT, summarized as follows:

¬ Spend less.

¬ Follow, don't lead.

¬ Focus on vulnerabilities, not on opportunities.

As has been argued extensively elsewhere [28] this constitutes a rather narrow viewpoint of IT's contribution to business where, amongst other issues, two important additional elements strongly affected by the performance of IT have to be explicitly recognized to correctly account for the business value of IT:

¬ (Business) processes.

¬ Information and knowledge management.

Moreover, if one measures business success only in terms of top-line revenues or bottom-line financial results (i.e., revenues less costs) then the only direct contribution of IT to overall business success is through IT cost savings (viz. a reduced IT budget) [29]. Any other value of IT may only be derived in an indirect fashion through different means or agents (for instance, people, automatization of processes, better decisions, etc.). As with all translations of concrete actions into strategic results the strategic planning then must incorporate some form of causal map linking IT investments to business benefits explicitly defining the cause-effect sequences throughout all relevant perspectives [30]–[33].

We also note in passing that competitive advantage (by IT or any other means) invariably depends on the notion of differentiation and scarcity [34], of doing things differently than one's competitors: Obviously, if enterprises end up using packaged applications in a highly preconfigured and standardized mode (such as SAP R/3, for instance, to save future migration and customization costs brought about by new releases of the application) they will forfeit any means of differentiation.

Heterogeneity and the n-tier Architecture

In many cases the development of the corporate IT function has not followed a smooth path of ever increasing continuous adaptation to the external environment. Instead it may be characterized by alternations between long periods with near stable infrastructure and systems and only incremental improvements (e.g., fine tuning communication links or enhancing the functionality of existing applications) and brief periods of almost revolutionary upheaval (e.g., introduction of a new ERP system, switching to a Service-Oriented Architecture).

This particular form of evolution, where near stasis is interrupted on occasion by rapid, extensive, and structurally significant change that corresponds with switches in IT strategies (punctuated equilibrium [35], [36]) has resulted in a situation typical for complex systems and is rightfully pronounced as "adaptation at the edge of chaos" [37]. We may categorize the IT function resulting from such a process of punctuational change as a distributed and heterogeneous n-tier architecture [38].

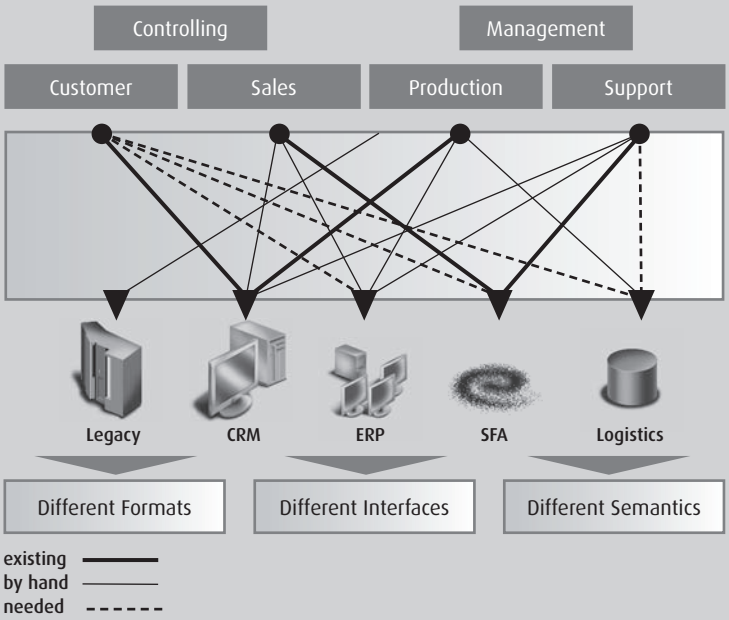


Fig. 2. Heterogeneous N-Tier Architecture

People working in sales, production, or support departments are separated from the actual and required IT capabilities by a widening gap of existing (but complicated), manual, or missing links to the applications and information systems (cf. Fig. 2.).

Additionally, this "silo" structure severely hampers cross-functional integration over more than one functional domain desperately needed for end-to-end process management or compliance issues (e. g., Sarbanes-Oxley or Basel II).

Furthermore, such a structure no longer permits the implementation of the necessary (strategic) agility of the business due to prolonged and failure-prone (software) development and deployment issues, a key internal requirement as demonstrated above in section II).

IV. PROCESS-DRIVEN ARCHITECTURE (PDA) MODEL

Characterization of the PDA Model

Well known architecture frameworks [13], [14] may be characterized to a certain extent by their rather complicated matrix structure encompassing sometimes in excess of 30 individual perspectives or domains to be investigated during a full-blown enterprise architecture project. More often than not this has resulted in failed architecture design (and, subsequently, implementation) efforts [39].

Recognizing that architecture constitutes one of the key areas of IT governance [40] this contribution takes the stance that "less is more" [41] and proposes – at the highest level of architectural abstraction – a four-layer model (depicted in Fig. 3) linking IT systems ("nodes" in UML2 parlance, corresponding to the "infrastructure" level at the bottom of Fig. 3.) and users (i. e., business stakeholders) at the top.

The individual layers attempt to bridge the "business–IT divide" by introducing a nomenclature understandable to business people and IT people alike. Layers progress in a hierarchical manner (i.e., higher level layers usually depend on lower level layers) and fulfill succinct missions and objectives.

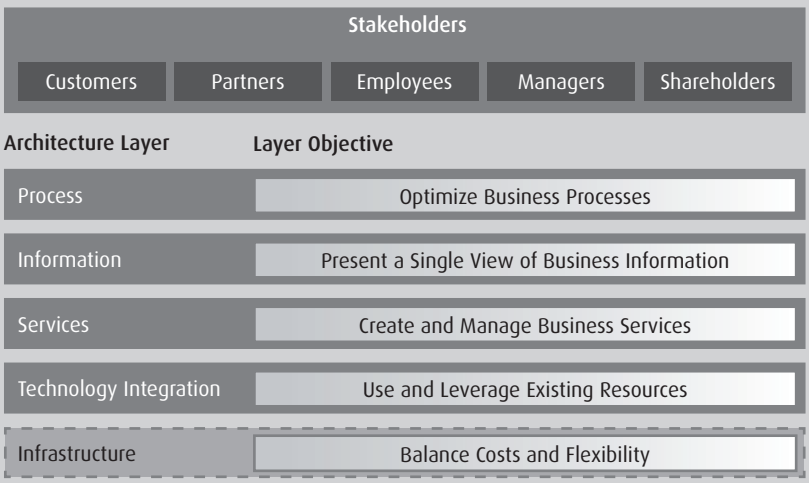


Fig 3. 4-Layer Concept of the Progress -Driven Architecture (PDA) Model

This 4-layer structure represents the most general decomposition of the PDA model and has to be complemented not only by a suitable IT infrastructure layer (e.g., [42]–[44]) but also by a more detailed internal description of the individual layers (e.g., [3], [13]).

We present our initial considerations and motivation for introducing these four layers in the Subsections B–E below.

Process Layer

Without doubt (business) processes and process improvements (after the near disappearance of the Total Quality Management [TQM] movement[11] the statistics based Six Sigma method currently seems to be the accepted approach *du jour*) already play a major role in corporate management. This is evidenced not only by the proclamation of a "third wave" of process management [46] after the (largely disappointing) business process reengineering fad in the mid 1990s [47] but also by recent advances in the theoretical foundations in the description of flexible processes [48] and the maturity and general availability of so-called Business Process Management Systems (BPMS) (cf. the Workflow Management Coalition membership directory for a presumably representative sample [49]).

With the organizational chart of an enterprise depicting the static structure of the organization the process view, by construction, allows analysis, design, management, and optimization of the dynamic structure of a business – which, as demonstrated in section II, constitutes a basic ingredient for achieving the necessary speed and agility.

Even though the workflow and process management community is still divided regarding the exact and unanimous definition of a process or a business process [50], [51] we have found the adoption of a pragmatic stance usually sufficient to initiate profound architectural discussions within the PDA model. For our purposes the following two definitions may provide a suitably sound and firm starting point within the PDA model:

A *process* is a structured and measured sequence of activities designed to produce a specific output based on defined input [52]–[54]. Or, to put it shortly, a process is a "structure for action" [52].

A *business process* is a complete dynamically coordinated set of collaborational and transactional activities that (i) delivers value to customers or (ii) fulfills strategic goals of the enterprise [46], [50], [53], [54].

Based on the last definition we observe that enterprises may only possess a limited number of *business processes* (usually 3 to 7) which constitute the highest level of a hierarchy of activities where business processes usually consist of several interlinked and interdependent individual processes.

Traditionally, process logic has been directly embodied in application flow and actual programming code resulting in vertically compact but horizontally independent application "silos" [55]. This disintegrated architecture, firmly embedded in the intricacies of the programs themselves, renders changes to the predefined set and dynamics of activities cumbersome and error prone, especially if one considers the rising demand for cross-functional integration.

Moreover, IT developers and programmers have thus taken considerable command over the very elements business users care about, namely the set of activities performed during their day-to-day work practices.

With the advent of reasonably powerful business process management systems (BPMS) for many enterprises this situation may change to the better, though. As a generic software system driven by explicit process design to enact and manage (operational) business processes [50] a BPMS should be capable of transgressing the shortcomings of the old way of application design and deployment.

The *process* layer of the PDA model, thus, allows to address and focus on these aspects.

Information Layer

Rarely, if ever, does IT consider information or information management as basic constituents of their accountabilities but IT management rather focuses on IT infrastructure or information systems (i.e., applications) management. This deficit is also to a certain extent reflected in current IT management or IT strategy literature [56]–[62].

Additionally, the usual entropy based theoretic definition of "information" given by Shannon [63] does neither serve the needs of corporate users nor is it able to develop a language between IT and business users in order to determine and align to their information needs. This stands in sharp contrast to the vigor and almost unrealistic hopes with which the even more advanced notion of knowledge management is pursued in some corporations.

We are convinced that a refocus of the corporate IT function on its prime responsibility of managing the conditions

[1] *This, interestingly, can be analyzed within the typical product life-cycle model resulting in the verdict that "TQM appears to have entered the phase of decline or degeneration in 2002" [45].*

of effective and efficient information production and delivery is able to provide a fertile ground for both redefining business value of IT and progressing further towards a knowledge-oriented (if not knowledge centric) business and competitive landscape.

Data exists all around us in the form of signals, events, or situations, which people can choose to interpret as potentially relevant or not relevant depending on their purposes. This, then, may lead to a decidedly user-oriented definition of information as "*data endowed with relevance and purpose*" [64].

In addition, information management (in our sense) is not restricted to IT management *per se* but has to be rooted in general management as well. Of course, business managers are necessarily generalists rather than (IT) specialists and, therefore, will approach information management with a holistic perspective. On the other hand, it is their responsibility to know and understand what information they need and use to make decisions and interact with people inside and outside the company [65]. Peter Drucker has called this expectation the *information responsibility* [66] of general managers.

Within our PDA model the *information* layer fills this perceived gap in IT and management thinking and practice and provides a means to address this topic within an enterprise architecture.

In addition to this paradigm shift regarding a new mission of the corporate IT function in information management we want to point out shortly that the current and rapid developments concerning the *Semantic Web* also serve as a motivation to explicitly recognize an information layer in our architecture model.

For our purposes it suffices to observe that Semantic Web initiatives aim at bridging the gap between the information encoded only in human readable form in the billions of web pages and the currently available tools (read: applications or programs) for creating, accessing, or extracting this information. The notion of the Semantic Web [67]–[69] tries to close this aperture by providing enhanced information access based on the exploitation of machine-readable meta-data. This partly involves advanced concepts such as ontologies, semantics, frame logics, and inference machines which, at this point in time (February 2007) are ready to be applied in an industrial setting but have not become routine (and, therefore, might serve as a means of differentiation through IT).

Services Layer

Two observations shall provide the foundation for introducing an explicit *services layer* into our PDA model.

Firstly, processes and workflows are naturally composed of certain activities which provide basic functions or capabilities to the agents (be that human or another piece of software) performing the different tasks within a process according to a certain process definition. Many of these functions, in one way or another, already have been implemented in application code and could and should be reused in different processes.

Admittedly, this describes a fairly ideal state of affairs and may be rarely observed in practice where reprogramming is the more common solution of reuse [70]. Furthermore, the entities or objects hinted at above constitute a (new) level of a technology independent abstraction usually called "services" [71], [72]. We will not argue for a particular or rigorous definition of this notion here but have found the following explanation fruitful in many discussions with IT and business management (loosely based on [70]–[72]):

A *service* is a well-defined, self-contained function fulfilling a particular business need provided by an application or module on request of another application.

Secondly, recent successes in international standardization efforts have, for the first time, resulted in sufficiently advanced and accepted standards regarding (Web) services which effectively allow the implementation of the abstract notion of "services" within an enterprise IT landscape (e.g., XML, SOAP, UDDI, WSDL, WS-I; see, for instance, [73], [74]).

Combining these two convergent ideas services represent, therefore, a suitable means to decouple process and activity logic from the actual technical implementations. Available technical means to implement services have reached a level of maturity where large-scale deployment of several hundreds of services typical for large enterprises has become feasible though not trivial [75].

Yet, changing to this service-oriented approach requires more than just the implementation of a technical service repository or an enterprise service bus. It demands a switch in attitude and, rightfully, necessitates a new architectural paradigm also encompassing applications development including service definitions. Within the confines of pure service-orientation this is commonly called a Service-Oriented Architecture (SOA) [70].

Nonetheless, we argue that this focus, though worth while to be retained as a dedicated *service* layer in our PDA model, is too narrow on its own and has to be complemented with the two higher-level layers of *information* and *process*

TABLE II. CURRENT ISSUES IN IT-ALIGNMENT

Layer	IT Issues
Process	¬ process design and modeling ¬ continuous process change ¬ process improvement programs (e.g., total cycle time [TCT], KAIZEN, Six Sigma) ¬ process management (optimization, visualization, simulation) ¬ workflow management including document routing
Information	¬ need for a single view ¬ data warehousing (DWH): auditing and rapidly changing ETL (extract-transform-load) designs ¬ dynamic and real-time information needs ¬ inconsistent meaning and different semantics of corporate data ¬ confusing (e.g., for customers) multi-channel data delivery ¬ lack of meta data ¬ knowledge management ¬ semantic web initiatives (RDF, OWL, etc.)
Services	¬ standardization of web services ¬ service-oriented architecture (SOA) ¬ linking the software development process (e.g., RUP, MDA) with application deployment and mgmt ¬ mobility ¬ access for different user devices ¬ bridging the "business – IT divide" between truly needed capabilities and actual technical implementation.
Technology	¬ tapping and unleashing the (still useful) logic and functions of Integration legacy systems and applications (e.g., mainframe, AS/400) ¬ functional integration: formatting, transformation, routing ¬ technical enterprise application integration (EAI): message-oriented middleware (MOM), message queuing

integration (see above in subsection B and C) in order to allow IT to fully leverage its potential.

Technology Integration Layer

Eventually, all abstractions mentioned above have to be implemented on an appropriate technical infrastructure in order to become operational and useful to business users. Given the fact that services still represent a rather abstract notion somewhat removed from the intricacies of current legacy IT infrastructure and systems we introduce the *technology integration* layer as the locus and conceptual domain where all necessary mediation actions shall be performed [76].

Suitable wrappers and adapters will not only provide interapplication communication in the sense of enterprise application integration (EAI) but also allow creating and providing services still embodied in non-service-oriented application code. This also recognizes the constraint that no enterprise can afford, neither in time nor in costs or in complexity of undertaking, to completely exchange their existing information systems landscape with purely service-oriented applications. Instead, the *technology integration layer* shall provide a means for gradually switching to a service-oriented (SOA) and process-driven architecture (PDA) – once the basic paradigm change has been accepted and enacted (which would constitute a so-called "punctuation" event [35]).

V. APPLICATION OF THE PDA MODEL

Mapping the Status Quo

We first demonstrate the usability of our PDA model by mapping current IT and business alignment issues to the four layers (cf. Table II).

Evidently, many if not most of these issues may be mapped to our PDA model, thus validating the model on the descriptive level.

Designing the Future

This subsection intends to show that the PDA model is a suitable prescriptive method for planning a future mode of operations.

Firstly, we observe that the hierarchical four-level structure of the model enables truly strategic planning conducted within a road-mapping approach [77]. Thereby the time evolution at the individual levels may be drawn in the horizontal dimension while causal relationships may be simultaneously depicted in the vertical dimension of the model.

Secondly, we note that our PDA model, by virtue of its layered and hierarchical composition, easily allows the identification, specification, and elaboration of cause-effect relations necessary to demonstrate the return on investment (ROI) for any change initiative. Following the sequence:

IT infrastructure (if necessary)
¬ information systems (IS)
¬ technology integration
¬ services
¬ information (and knowledge)
¬ processes
¬ business value
(cf. the stakeholders in Fig. 3)

one investigates the effects of a particular decision or event on one layer at the next (higher) level, the results of this change on the next (higher) level, and so on. Thereby a full causal chain may be quite rigorously established linking initial IT investment to tangible business results.

The general systems thinking community has recognized decades ago that it is necessary and actually enlightening to employ such cause-effect analysis in order to predict the reaction of any reasonably complex but otherwise general system to certain events (see, e.g., [31] for further references). Nonetheless, this line of thought has been independently "rediscovered" or at least reapplied (sometimes without due credits) several times by a few researchers (including the author himself [32]) in various areas including IT:

¬ corporate strategy – balanced scorecards [30]
¬ organizational learning – the "5th discipline" [78]
¬ IT investment evaluations/ROI calculation – "cause-effect diagrams" [32]; "dependency network diagrams" [33]; "result chains" [79]

Thirdly, we want to introduce a (novel) information- and process-centric way of structuring the divide between business strategy and information technology partly influenced by [62], [80], [81].

We begin our deliberations by highlighting (and, admittedly, oversimplifying) the fact that IT is only apt at and truly excels in producing and transforming raw data (viz. bits and bytes). Even the introduction of the term "information" (characterized not by the usual entropy-based definition of Shannon [63] but in a Batesonian manner as "data which makes a difference", cf. [82]) presupposes and requires an external frame of reference outside IT.

However, even when IT people talk about "information management" they seldom address the question: "What do we need information for?"

As shown in Fig. 4 information is needed for three different but interlinked purposes:

¬ making decisions
¬ enacting and controlling processes
¬ creating and managing knowledge

Clearly, these three areas are mutually (actually: cyclically) dependent and combined with the people actually enacting

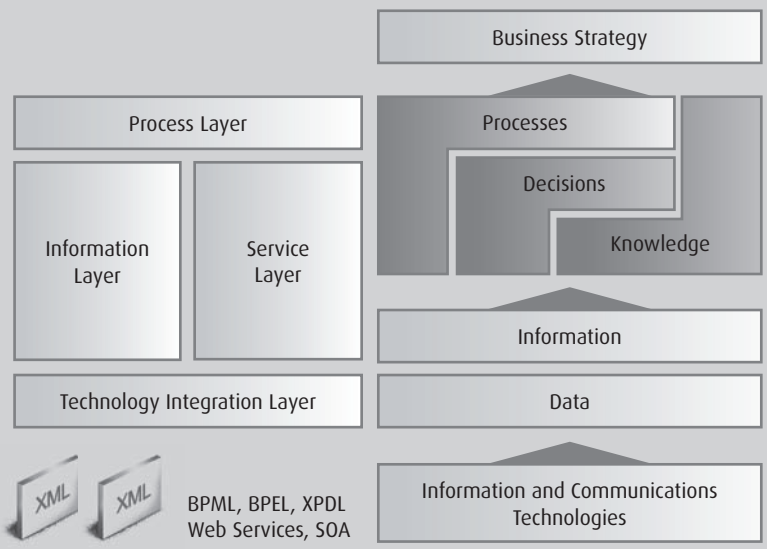
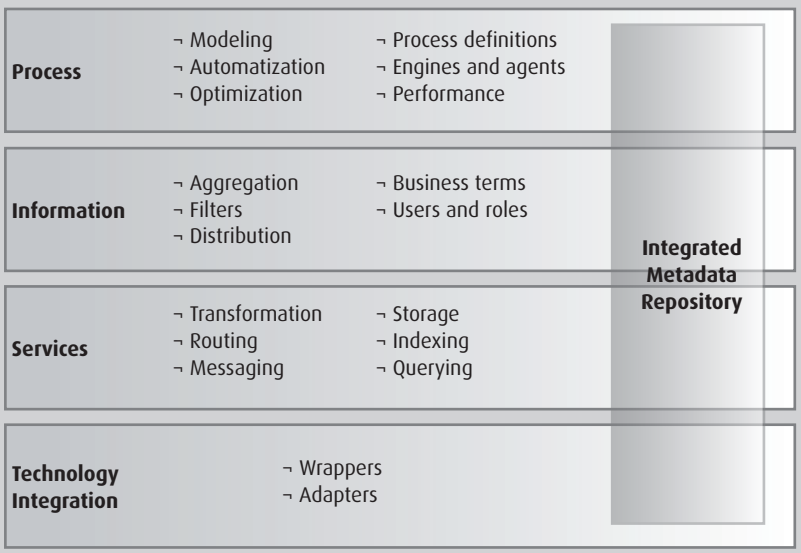


Fig. 4. Linking the PDA layers to business strategy execution

TABLE III. THE NEED FOR METADATA INTEGRATION

Layer	Metadata requirements and issues
Process	¬ process definitions
	¬ process performance indicators
	¬ process enactment specification
	¬ process monitoring and auditing
Information	¬ semantics and ontologies
	¬ information flow
	¬ decision making procedures
	¬ knowledge representation and management
Services	¬ service descriptions
	¬ quality of service (QoS) and service levels
	¬ location transparency
Technology Integration	¬ deployment and technical run-time specifications
	¬ syntax descriptions and translations
	¬ communication definitions

Fig. 5. Vision of the integrated metadata repository linking the Four layers of the Process-Driven architecture



the intended behavior, constitute a fully developed "system" in a systems thinking [83] or social systems sense [78], [84]: processes rely on timely decisions, decisions depend (hopefully) on acquired prior knowledge (e.g., by applying Bayesian inference logic [85]), and business management certainly wants to obtain knowledge about their decisions and processes.

At the left of Fig. 4 we have denoted how extraordinarily well the four layers of our PDA model fit into this scenario.

As a fourth and final application of the PDA model to the design of a future corporate IT function we discern the strong need for metadata at each of the individual four layers of the model (cf. Table III).

Yet, this layer-specific metadata also needs vertical (i.e., cross functional) integration as well (cf. Fig. 5). Take, for instance, the (still unresolved) problem of (web) services orchestration and coordination [86]–[88]. This metadata originates or has to be deployed in a consistent and exhaustive manner at the process layer (specifying the sequences of activities within a process), at the service layer (resolving issues of distributed transactions, compensations, and failures), and at the technology integration layer (mapping abstract services to concrete run-time instances at certain nodes).2

In a similar vein information driving processes (e.g., at decision points) has to be consistent with the information elements available through the various information sources (e.g., data warehouses) scattered across systems from a semantical point of view.

Even though IT suppliers and software vendors have not mapped out the PDA model in the same detail and care as this contribution we would want to point out that IT industry (e.g., IBM, SAP, Tibco, Software AG, and others) is also heading in

this direction, namely towards implementing (though under various guises) a similarly layered enterprise architecture where the different levels are linked via a suitable metadata repository.

However, at this point in time February 2007) individual vendors differentiate clearly in their ability to execute and the completeness of their vision (scil. of the PDA architecture model): *caveat emptor*.

VI. CONCLUSION

This paper introduces, defines, and employs the 4-layer process-driven architecture (PDA) model as a conceptual tool for bridging, from an enterprise architecture point of view, the divide between business and IT.

The PDA model fills a perceived gap in current IT technology management thinking and practice by (i) clearly focusing on business needs and demands and (ii) by putting forward an approach revolving around the very notions of information management or information logistics instead of information technology or information systems.

By explicitly introducing the terms *processes* and *information* (taken also as a precursor of knowledge) it focuses managerial attention on the essentials of how to view business strategy and the required organizational capabilities to generate, disseminate, and use information to improve performance.

The *service* and *technology integration layers* permit IT specialists and business users alike the participation in a mutual discussion on how expected or required business capabilities and functions shall be mapped to or embodied in information systems.

This not only assists all stakeholders in creating a shared language within which to address current issues and to resolve the future evolution of their corporate IT function, but also aids in truly aligning information and information management (not: IT or IS) to the particular and contingent strategic priorities of their firms.

VII. ACKNOWLEDGMENT

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