An Enterprise Physics Approach for Evolution Support in Heterogeneous Service-Oriented Landscapes

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Abstract. We present an incarnation of the Enterprise Physics vision sketched in [3] that provides automatic or semi-automatic support for evolution and change management in heterogeneous legacy landscapes. In our approach, 1) legacy heterogeneous, possibly distributed platforms are integrated in a service oriented fashion, 2) the coordination of functionality is provided at the service level, through orchestration, 3) compliance and correctness are provided through policies and business rules, 4) evolution and correctness-by-design are supported by the eXtreme Model Driven Development paradigm (XMDD) offered by the jABC [2] - the model-driven service oriented platform we use here for integration, design, evolution, and governance. The artefacts are here semantically enriched, so that automatic synthesis plugins can field the vision of Enterprise Physics: knowledge driven business process development for the end user.

1 Enterprise Physics: Vision or Reality?

Enterprise Physics [3] is a metaphor for a new way of defining how enterprises work and the environment in which they operate. The Enterprise Physics metaphor defines the set of virtual laws that govern the enterprise

- Constrained by laws, standards, contracts, policies, legal codes, regulations
- Constrained by available resources, services, time,
- "Attracted" to the company's and individual goals

In such a world, the principle of management and governance is *Go where allowed - and if more alternatives are possible, choose where preferred.*

As we advocate it, enterprise physics is for enterprises and organizations the equivalent of a rational mechanics for material bodies. This is a rather new way of conceiving the enterprise and its environment. It empowers IT, in the sense that it makes the "rules of the game" explicit, thus auditable, measurable, even certifiable. It also empowers and protects management: once it is made clear what is strictly mandated, what is strictly forbidden, and what is the playground for shaping business strategies and defining business opportunities, there may be a vision of correct and complete (IT-backed) methods that enforce the strict do's and don'ts, and additionally optimize choices in the business opportunity area in between.

Our thesis is that much of the technology needed for this is already available today, and that today's platforms are ready to start introducing Enterprise Physics concepts and technologies in businesses. We illustrate it on a small reference example well known in the community of Semantic Web Services.

Nevertheless, Enterprise Physics is today still a vision. The reason is that it has an inherently strategical character: Much like telecommunication networks and the Internet, it cannot be realized at a single point, or by a single business, or among a few single corporations. Its power and the benefits for everybody can unfold and flourish only when sufficiently many adopt it and participates. The contribution of the present work is to provide a proof of concept, and only compelling proofs of concepts make visions effectively communicable.

In the following, Sect. 2 relates the enteprise Physics vision with the SWS Challenge, Sect. 3 gives an overview about the chosen case study: the Mediation Scenario of the Semantic Web Service Challenge. A brief outline of the solutions with jABC/jETI Technology is given in Sect. 4, and the intended way of modelling update is sketched in Sect 5, where we consider the integration of functionality from SAP's ERP Enterprise Services suite. Sect. 6 finally draws our conclusion.

## 2 Enterprise Physics and the Semantic Web Service Challenge

Especially in the area of enterprise application integration the new possibilities opened by the Service Oriented Computing paradigm, applied to Web services, are appealing: the idea of service-oriented computing and the envisioned availability of thousands of services to be leveraged to provide agile business processes is a vision shared by all major players in the enterprise software market and by their customers.

An Enterprise Physics realization will therefore likely base on such an SOA/SOC paradigm, as outlined for example in the Policy Oriented Enterprise Management approach of [3,4], and substantiated in the *one thing approach* proposed by [7] from the methodological and realizational point of view.

However, Enterprise Physics can not be fully leveraged as long as service oriented applications are described merely in terms of the service's signatures, as in current WSDL. The lack of rich information on the kind of service offered, and under which circumstances it is applicable and/or adequate is largely responsible for the fact that composite services and applications that use services are created and maintained manually. Semantic technology, of the kind that enhances the service descriptions by annotations that precise its behaviour, for a certain application domain, beyond the signature information is a minimum requirement. Semantics is understood in this context as extended descriptions by means e.g. of ontologies, or pre- and postconditions. If this kind of semantics were carefully designed and automatically supported by tools, the tasks of service discovery, selection, negotiation, and binding could be automated, lifting service-oriented applications to a new level of adaptability and robustness.

There, semantic issues play a central role in two directions:

– expressing the purpose of the compound service, i.e.
    What should the compound service achieve?
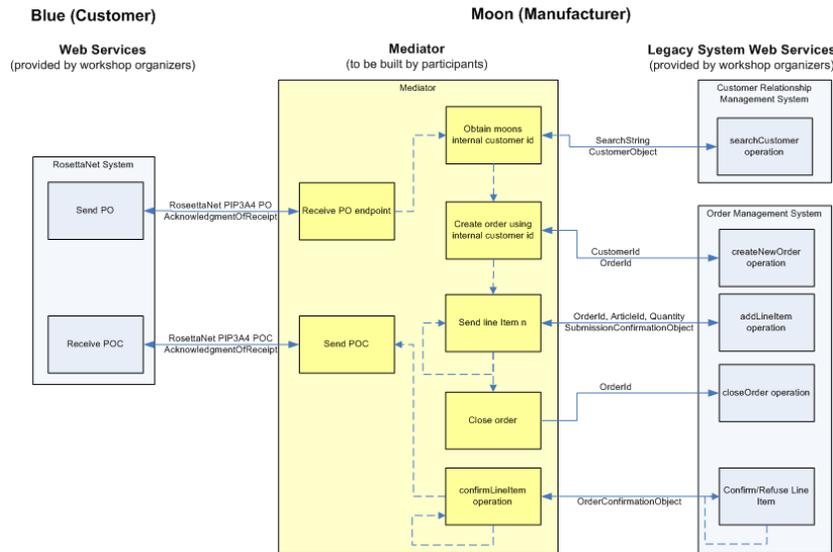
Fig. 1. Abstract View of the SWS Mediation Scenario

– expressing the suitability of the single services that appear in the service composition, i.e.

Once it is clear *how* to orchestrate single service functionalities to achieve that purpose, *what* (available) services are adequate to provide the functionalities required in the orchestration?

This reminds strongly of the question *From the How to the What* we addressed at VSTTE 2005 in Zürich [6], where we considered the VSTTE Grand Challenge under a very specific (and Service-Orientation friendly) perspective: the enabling of application experts without programming knowledge to reliably model their processes/applications in a fashion that allows for a subsequent automatic realization on a given platform. This goal, which aims at simplifying the tasks of the many at the cost of ambitious and laborious tasks for the few, adds a new dimension to the techniques and concepts aimed at by the Grand Challenge: the application-specific design of platforms tailored for the intended goal. We were convinced already then that the outlined perspective provides a realistic and economically important milestone for the Grand Challenge.

The SWS Challenge [1] addresses exactly this goal, albeit in a Web Service context instead of general programming:

– how can one specify, as clearly and declaratively as possible, the *What's* in the previous two questions, and
– how can one achieve as automatically, adaptably, and robustly as possible the implied *How's*, concerning *composition* (orchestration) and *matchmaking* for the single services (or components).

In fact, many different approaches to semantic Web service descriptions are already available, and many frameworks are built around them, yet a common understanding, evaluation scheme, and testbed to compare and classify these frameworks in terms of their abilities and shortcomings is still missing.

The purpose of the ongoing *Semantic Web Service Challenge* [1] is precisely to develop the lacking common understanding of the various technologies intended to facilitate the automation of mediation, choreography and discovery for Web Services using semantic annotations. This explores trade-offs among existing approaches and reveals their strengths and weaknesses, as well as aspects of the problem space that are not yet covered.

In [8] we examined the concrete settings, the dimensions of complexity that appear in the Challenge, and reflected on the essence of the observations so far. More detailed information on the activity and results so far can be found in [1]. A book collecting the revised results will appear with Springer Verlag later this year [9].

2.1 The Problem Scenarios

The challenge problems are realistic e-business scenarios in purchase order management, organized into major problem levels with sub-problem variations, with changes in the web services, the protocol of interaction, and the purchase order in consecutive variations. Two scenarios address different aspects of the Semantic web techniques:

- The *mediation* scenario concerns making a legacy order management system interoperable with external systems that use a simplified version of the RosettaNet PIP3A4 specifications[1]. It concerns therefore finding an adequate *orchestration* that adapts two conversation partners that mismatch both in the interaction protocol and in the granularity and format of data.
- The *discovery* scenario concerns the dynamical discovery, selection, binding, and invocation of the most appropriate shipment service for a set of given shipment requests. This scenario addresses *matchmaking* for the single services.

We relate here the Mediation Scenario to the Enterprise Physics vision.

3 The Original SWSC Mediation Scenario: Process and Data Mediation

The very basic scenario concerns here purchasing goods using a simplified version of the RosettaNet PIP3A4 specifications. Figure 1 shows its three main components:

- the **Company Blue**, a customer (service requester) ordering products,
- the **Mediator**, the sought-for piece of technology providing automatic or semi-automatic mediation for the Moon company, and
- the **Legacy System** of the Moon Company

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[1] http://www.rosettanet.org/PIP3A4

While the external interfaces must follow the RosettaNet specification, internally Moon uses a propriety legacy system whose data model and message exchange patterns differ from those of RosettaNet. Participants shall basically enable Moon to "talk RosettaNet" and implement the *Purchase Order receiving role* part of the interaction described in the RosettaNet PIP 3A4.

Both the Moon legacy systems and the customer Web services (Blue) are provided by the challenge organizers as technical infrastructure accessible online, and can not be altered (although their description may be semantically enriched). The sketch of the mediator of Fig. 1 requires two services (one from the RosettaNet request to the CloseOrder, called Part 1 and one for the order confirmation, called Part 2) and shall be implemented by the participants.

To manage its order processing, Moon uses two back-end systems:a Customer Relationship Management system (CRM) and an Order Management System (OMS), both accessible on the SWSC testbed through public Web services described using WSDL. The scenario describes how Moon has signed agreements to exchange purchase order messages with its client (Blue) using the RosettaNet PIP 3A4 specification.

In order to address integration of the Blue and Moon companies, the participating groups are encouraged to use SemanticWeb service technology to facilitate conversation between all systems, to mediate between the PIP 3A4 and the XML schema used by Moon, as well as to ensure that the message exchange between all parties is correctly choreographed. In particular,

- **Data mediation** is involved in mapping the Blue RosettaNet PIP 3A4 message to the messages of the Moon back-end systems.
- **Process mediation** is involved in mapping of message exchanges defined by the RosettaNet PIP 3A4 process to those defined in the WSDL of the Moon back-end systems.
- **Conversations** between the systems including data and process mediation operate on semantic descriptions of messages, thus requiring the transformation from messages used by existing systems to the ontological level.

The SWSC organizers provide a set of challenge problems that build upon this initial mediation problem. Correct solution of the basis Mediation Scenario is determined automatically by the SWSC testbed: it tests and certifies that the solution is able to carry out the basic conversation. Subsequent levels foresee changes in some aspects of the problem. The evaluation criteria concern here the degree of declarativity of the solution: ideally, using semantics the middle layer should be able to autonomously react to changes made inside the process specification.

This is the truer, the closer we are to an Enterprise Physics scenario and support technology.

4 Outline of the Solutions

The generic structure of the solution is shared by all the approaches:

- extract the *relevant* information from the *PurchaseOrderRequest*

- call Moon's Customer Relation Management (CRM) to find the customer data inside the database, if she already has an account.
- Use the *CustomerID* to create an order using Moon's Order Management System (OMS).
- add *LineItems* as needed and then
- close the order.
- Finally the middle layer receives an *OrderConfirmationObject* and
- sends a *PurchaseOrderConfirmation* back to Blue.

This is in our opinion an adequate demonstrator for Enterprise Physics in practice.

Within Physics we consider in particular Rational Mechanics for this setting. Rational mechanics studies the trajectories in space and time of (abstract) bodies. *Bodies* have properties, and they are subject to forces and constraints. The movements of each body and stability conditions (equilibrium) depend on the objects, their properties, an initial state, and of course on the applied forces and on the constraints, represented by other bodies (a heavy wall, that cannot be passed and forces a bounce), general conditions (2D space vs. 3D space), or generic rules of the games that actually are also forces (e.g. the effects of fields, like gravitation on Earth vs. absence of gravity in space). In this model paradigm, bodies exposed to forces and to constraints obey well known, simple and elegant laws of physics. As a consequence, a) it is possible to predict by computation what given bodies in a given situation will do, and b) it is legitimate to believe in the results, within the limits of the assumptions one made (e.g. non-relativistic speed, point-mass instead of distributed mass, constance of the gravity constant,...).

Unlike physics, enterprise management is still considered an art, guided by creativity, experience, and rules of thumb. However, large portions of the business are amenable to being run more efficiently and more reliably within an enterprise-related model analogous to the rational mechanics paradigm sketched above. Business processes like the ones addressed in the SWS Challenge are an enterprise management area suitable to illustrate this modelling and its benefits.

In the enterprise physics analogy, in a first approximation sufficient for this case study, the enterprise entities we observe and use are

- *business objects* like line items and orders, comparable to things in the physical reality like atoms, molecules, or larger compound bodies, and
- *services*, like ordering or order confirmation, that act upon or happen to them, comparable to chemical reactions, motion, or deformation.

Like in classical physics these entities are treated *abstractly*, like a massive body is commonly abstracted to a point (its center of gravity), characterized by (numerical) *properties* associated with them like its mass, its size, or its (again abstract) constituents.

In enterprise physics these properties reflect the business perspective:

- Typical properties of the *business objects* are their constituents, their purpose, and their types. We capture them in abstract *semantic types*, and express them as predi-
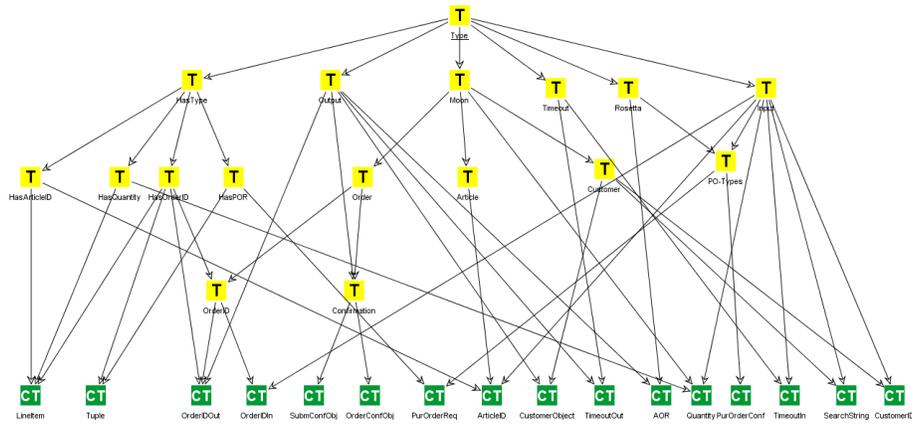
Fig. 2. The Type Taxonomy for the Platform Migration Scenario: Nothing needs to be modified

cates in a taxonomy[2] of types (see Fig. 2 and 3 for the type taxonomies used in this case study).

– Similarly, *(business) services* are classified according to their purpose, that we capture in abstract *semantic activities*, that are expressed as predicates in a taxonomy of activities (see Fig. 4). They are grounded to real implemented services, so among the properties one can find the implementing body, the URL where they can be accessed, and additional facets that address non-functional aspects like e.g. efficiency, authorization, preconditions, licensing or usage limitations.

The *relation* between services and the business objects they act upon is expressed in the simplest instance by stating for each service activity which types it requires and which types it produces (see Tab. 1 and Tab. 2). Besides these simple typing rules, *local constraints* comprise additional properties of the entities they pertain to, and can be expressed by other predicates in those taxonomies or by constraints in some logics. Examples here are relations between (mutual supportive) neighboring services, or between services and business objects. In the SWS mediation scenario the local constraints are captured by relations and closures over those taxonomies. In the physics analogy, a spring may be attached to a solid body, but not to an atom or a molecule (typing constraint), and if attached, it explicitly constrains the bodies motion it in a mathematically expressible way.

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[2] Taxonomies are a subtype of ontologies that expresses membership relations, like the common *is-a*, *has-a* occurring in the case study. We can deal with more complex relations as well, but for the purpose of illustration we keep to these in this paper.
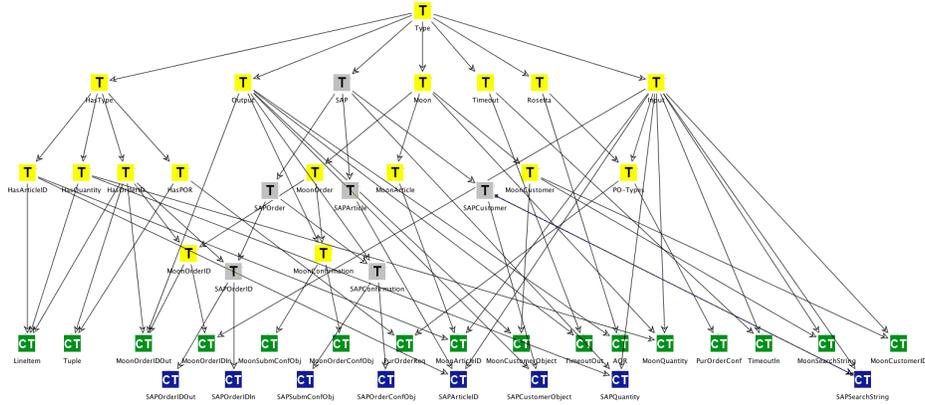
Fig. 3. The Type Taxonomy for the Backend Enhancement Scenario, with ERP-Related Instance and Concept Types

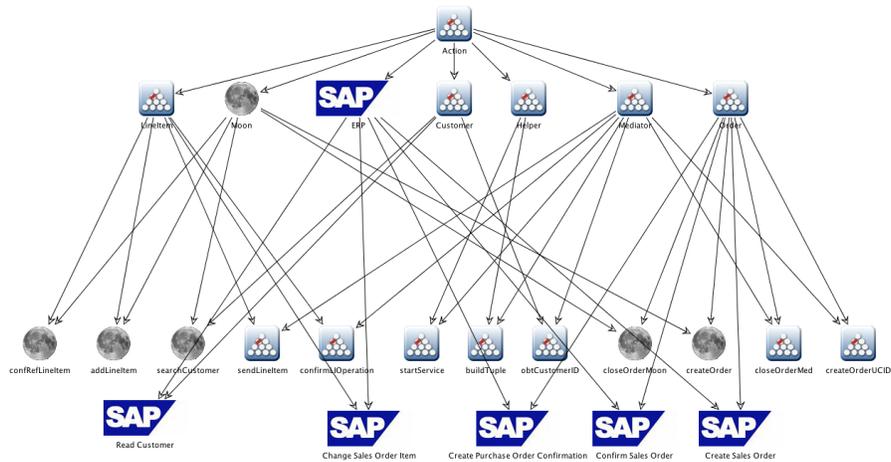| MOON SERVICE	SAP ENTERPRISE SERVICE
Search Customer	Read Customer
Create Order	Create Sales Order
Add LineItem	Change Sales Order Item
Close Order	Confirm Sales Order
Confirm/Refuse LineItem	Create Purchase Order Conf.

Table 1. The Service replacement map for Moon's new ERP backend.

5 Modelling Structure and Update

In the concrete SWS mediation scenario considered, we examine a scenario update where a new realization with SAP Enterprise Services leads to a replacement of Moon's service components as depicted in Table1. The corresponding mapping of the Business Objects is shown in Table 2. Both tables express this local type of constraints, that here basically define equivalence relations from the business point of view.

In contrast, *global constraints* are similar to physics' (electromagnetic or gravitational) fields and boundary conditions. Global constraints influence the entire scenario and likely last along its entire evolution. For example, German data protection laws in Germany or other rules of compliance have the same character as gravity on earth: they must be respected in any business handling. As a more application specific example one may formulate that is is not possible to confirm an order that has never been issued.

The characterization, rules and constraints described up to now establish a typically quite large space of possible solutions: everything which does not (directly) violate the physical or business rules. The physical reality (at least in the macroscopic world), however, does not happen by (pure) chance, but is quite deterministic. This is due to some 'economic' principles of the physical world, which, e.g., prefer minimal energy

Fig. 4. Platform Migration: The Action Taxonomy with added SAP ERP services.

SAP ENTERPRISE SERVICE	BUSINESS OBJECT
Read Customer	Customer
Create Sales Order	Sales Order
Change Sales Order Item	Sales Order
Confirm Sales Order	Sales Order
Create Purchase Order Conf.	Purchase Order Conf.

Table 2. The Business Objects replacement map for Moon's new ERP backend.

states. In enterprise physics these principles reflect business objectives, like profitability, growth, efficiency etc.. Fig. 5 shows the synthesized set of all *minimal* solutions of the mediation scenario, as a basis for a further user-driven refinement, e.g. in order to eventually end up with a cheapest or fastest shipment. Of course, this approach does not stop as soon as an appropriate solutions has been found. Rather, it allows one to successively adapt the found solution to new frame conditions by synthesis, without any need of programming.

In contrast to physics, where these principles are 'built in', we must enforce them by means of specific optimization techniques in the enterprise physics framework. In the SWS scenario, our current solution minimizes the number of steps of the synthesized process, in an indirect risk minimization approach: We assume that a process involving less services is more robust, since it depends on the well-functioning of fewer partners. Minimizing costs or involved parties would be alternative optimization goals.
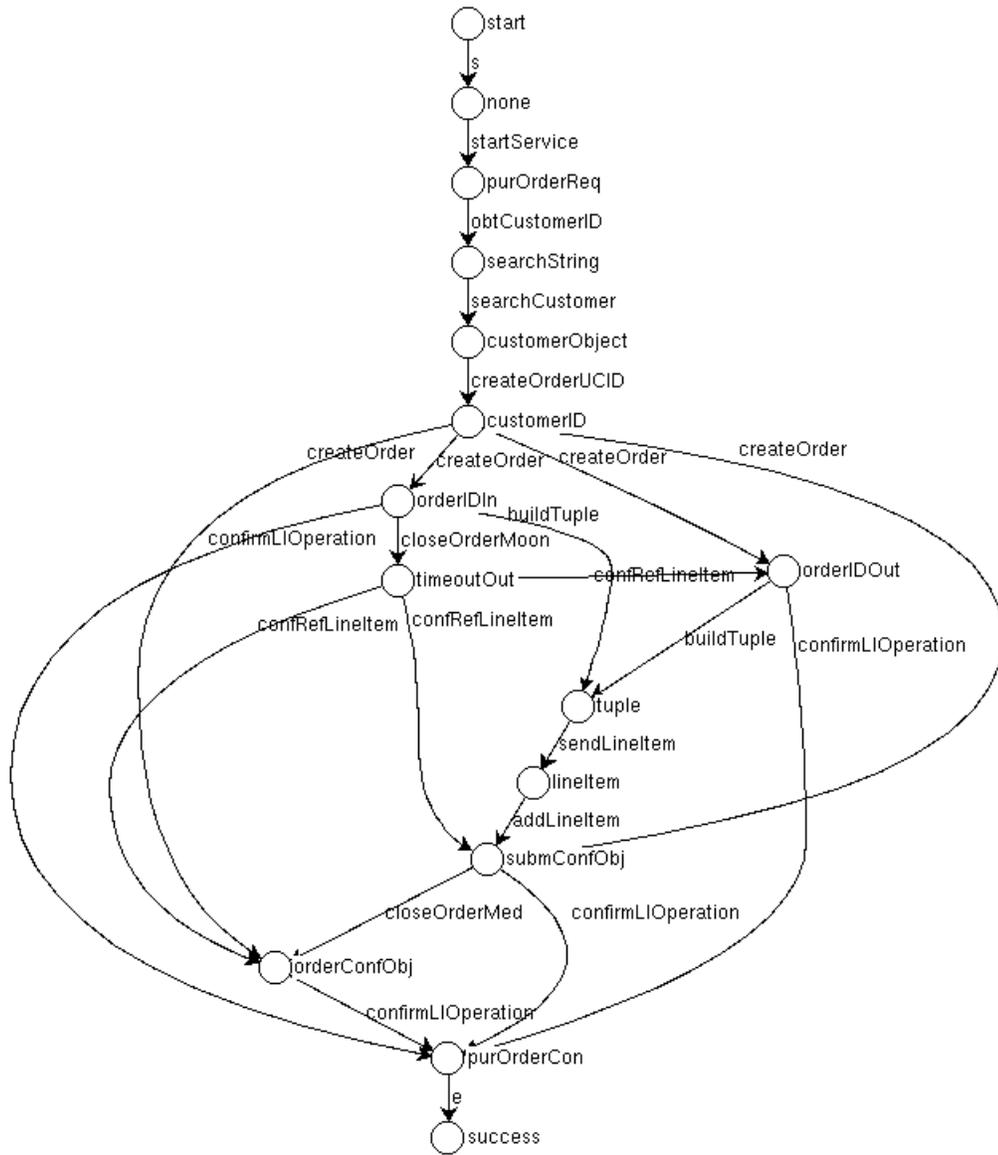
6   Conclusion

We have elaborated on the vision of Enterprise Physics sketched in [3] and illustrated the potential of a rule/law-based approach to business process modelling. Key to our approach is the service-oriented organization and integration of the various functionalities required for the individual process steps. This allows us to 1) integrate legacy heterogeneous and possibly distributed platforms, 2) provide the coordination of functionality at the service level, through orchestration, 3) guarantee compliance and correctness through policies and business rules, and 4) support evolution and correctness-by-design by the eXtreme Model Driven Development paradigm (XMDD) offered by the jABC [2] - the model-driven service oriented platform we use here for integration, design, evolution, and governance.

It is our experience that the Enterprise Physics paradigm helps here to successively build up a tangible feeling of the complex and global nature of a business environment. This happens on the basis of clear goals, rules and laws, made tangible through immediate feedback provided by the jABC framework. In particular, this allows one to understand the impact of rules, and to play with if/then-scenarios in order to explore the potential of intended changes at the business process modelling level. Central is the distinction between *resource modelling and functionality modelling* which establish the business objects, *local and global constraints*, which provide the technical frame conditions as well as legal requirements and policies, and the *economic principles* reflecting business objectives, like profitability, growth, and efficiency. This way, we can distinguish and individually address and update the business strategic levels of action and responsibility. We are convinced that this new kind of clear organization will ease the evolution of business processes, shorten the time to market, and yet increase reliability and control.

References

1. Semantic Web Service Challenge Website, `http://www.sws-challenge.org`
2. Margaria T, Steffen B: **Aggressive Model Driven Development for the Management of Service Evolution**. *Annual Review of Communication* 2004, **57**.
3. M. Kaiser. Towards the realization of policy-oriented enterprise management. *IEEE Computer Society Special Issue on Service-Oriented Architecture forthcoming*, 11:65–71, 2007.
4. M. Kaiser and J. Lemcke. Towards a framework for policy-oriented enterprise management. In *AAAI*, 2007.
5. *Special Session on* SerComp & SWS Challenge 2007 Workshop*, IEEE/WIC/ACM Int. Conf. on Web Intelligence (WI 2007), November 2007.*
6. T. Margaria and B. Steffen. From the how to the what. In *VSTTE: Verified Software—Theories, Tools, and Experiments, Proc. IFIP Working Conference, Zurich, Oct 2005*, 2005.
7. Bernhard Steffen, Prakash Narayan: Full Lifecycle Support for End-to-End Processes, IEEE Computer, vol. 40, no. 11, pp. 64-73, Nov., 2007
8. T. Margaria: The Semantic Web Services Challenge: Tackling Complexity at the Orchestration Level, Proc. ICECCS'08, 13th IEEE Int. Conf. on Engineering of Complex Computer Systems, Belfast (UK), April 2008 (invited talk).
9. Semantic Web Services Challenge - Results from the First Year, C. Petrie, T. Margaria, M. Zaremba, H. Lausen (eds.), Springer Verlag, (to appear).

Fig. 5. The Minimal Solutions