Collaborative Product and Service Life Cycle Management for a Sustainable World

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Collaborative Product and Service Life Cycle Management for a Sustainable World

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Preface

There is now an overwhelming body of scientific research and political opinion which agrees that current patterns of energy and materials usage are unsustainable, whether in terms of availability or environmental impact. The problem is twofold. In the short-to-medium-term, the current approach to development is sub-optimal through inefficient utilisation of the world's resources while also causing unnecessary irreversible or long-term damage. In the medium-to-long-term, the earth's depleting resources and bio-physical systems will struggle to withstand the exponential burden of over-population even at reduced levels of human ecological footprint. The severity of the problem is evident if one considers that the world's 43 main deltas are predicted to be under water within decades, removing one of the earth's most productive food regions that also happens to correspond to areas of significant human population density. The challenges that face us tomorrow have already started yesterday and are shaped by the things we do today, or indeed do not do. Our lives today are based on the most basic manifestations of progress, such as quality of sustenance, domestic and social environments, mobility and leisure, and most significantly, are based on convenient and reliant energy production in the consumption and use of the world's resources. However, we are now at a turning point where we need to make decisions with objective reference to our longer-term quality of life, with respect to our own future generations and the 'global ecological justice' for those in all parts of the world. Sir David King (UK Chief Governmental Scientist) is of the opinion that climate change is a bigger threat than global terrorism and is the key challenge for the 21st century. However, the recent Stern Report (2006) proposed that the economics of meeting and working with climate change to achieve a sustainable future is not out of scale with current and future economic potential. Therefore, concurrent engineering through collaborative enterprise will have a crucial role in the 21st Century in the provision of a balanced solution to industrial and economic activity that respects environmental and sustainability requirements.

In the context of sustainable industry, companies must provide their products and services with greater resource efficiency and/or a reduced negative impact on the environment. In industrial processes, this would mean energy efficiency, resource conservation to meet the needs of future generations, safe and skill-enhancing working conditions, low waste production processes, and the use of safe and environmentally compatible materials. This can only be achieved for products and services through a concurrent engineering approach to a life-cycle balanced solution. Until recently the emphasis in industrial processes has been on improving the energy efficiency and, due to legislative requirements, there has been a shift towards improving the safe working conditions and skill-training of the work force. However, the current strategy is to give more emphasis to resource conservation, by a process of not only “reduce, reuse and recycle” strategies, but also through innovative designs and the use of environmentally compatible materials. Materials technology is now seeing the utilisation of nano-composites to enhance mechanical and biodegradability of polymers while advanced composites are being used in applications ranging from bridge decks to aircraft wings. Structural composites, polymers and even geopolymers are increasingly used in both aerospace and construction industries to provide increased structural performance whilst reducing the volume and weight of materials, and the energy used to manufacture them. The value of good design and engineering is becoming more and more prevalent in the balance between meeting customer demands at an acceptable cost; whether economic, social or environmental.

Allied to the current strategy being taken up in many developed countries is the adoption of environmentally friendly and low carbon technologies, in which the release of greenhouse gases, such as carbon dioxide and nitric oxide, is kept to a minimum. Industry and the built environment are enormous users of energy whether directly in processing or through the treatment of waste; some 40% of CO2 is generated by buildings and the cement industry alone producing upwards of 5% of the world’s CO2 emissions. In tandem with technological and process improvements, the economic incentive for concurrent engineering excellence may be enhanced and aided by certain economic instruments; such as carbon taxation and tradable pollution permits to name but two debatable examples. However, in today’s concurrent and collaborative engineering environment, reduction of carbon dioxide is being achieved by a combination of innovative approaches in the design and manufacturing process, operations, and the utilisation of materials, with supporting recycling and waste management strategies.

Another high profile example of the challenges facing use today is the aerospace industry, which accounts for some 2% of global CO2 emissions but is heavily dependant on oil, an energy source on which the world is overly dependent. The world’s oil reserves are finite in the medium term but yet there is an immediate business, leisure and defence dependency on the compressed transportation time offered by air travel. There are also serious ecological impacts of air travel due primarily to pollution but also noise, as identified by ACARE in their VISION 2020 initiative. However, the demand for air transportation is predicted to rise exponentially over the next few decades, leading to a much greater potential impact on the environment. For this reason, the European Union has set targets for the year 2020 that include a reduction of nitric oxide emissions by 80%, carbon dioxide by 50%, noise by 12 dB, and cost by 50%, with a five fold increase in safety. These targets have set challenges in the aerospace community in terms of innovation and integration that will necessitate state-of-the-art concurrent engineering practices. The introduction of emission trading in the aviation industry may provide further economic incentive for reaching some of these targets but dramatically new solutions from a concurrent engineering approach are being demanded in propulsion technologies and fuel, energy consumption, vehicle design, air transportation management and environmental footprint management.

The immediate response of many countries and governments has been to set ambitious targets in the field of renewable energies. For example, The Renewable Obligation of the UK targets an increase in the proportion of electricity provided by renewable sources of at least 10% by 2010, with suppliers to source a specific and annually increasing proportion from renewables until 2027. As well as wind and solar, this has led to renewed interest in marine renewable energy in the form of ocean waves and tidal currents as a vast and virtually untapped resource. However, the concurrent engineering challenge of harnessing this to produce economic and reliable energy is considerable; its commercial exploitation being in its infancy but expanding rapidly. This is all in the context of renewed interest in the potential solution provided through nuclear energy, perhaps best representing the complexity of the trade-offs to be considered in addressing the provision of energy to support our 21st Century lifestyles and patterns of consumption, but in a truly sustainable manner.

It is certain that socially, contemporary and future policy design in relation to combating climate change and managing the transition towards a post-carbon energy economy will require the ‘upstreaming’ of public engagement and widespread public acceptance and ‘buy in’. Equally, the rise in the geo-political importance of ‘energy security’ has now become coupled with the policy and political debates around climate change and renewable energy generation. An issue here is the politics and deliberate use and misuse of the science around climate change within the popular media, making the whole issue of climate change and our responses to it confusing and non-coherent for many citizens, consumers and policy-makers. These social and political considerations must be incorporated into the concurrent and collaborative engineering enterprise in order to make research policy-relevant as well as scientifically and technologically innovative.

It can be concluded that sustainable development is actually very positive in not only seeking technological solutions through a restricted short-term market view but rather, through a more expansive truly concurrent approach that must be adopted in synthesising all of the far reaching requirements and implications relating to products and their intended operation, service provision and end-of-life. The need for sustainable development is increasingly driving the market to reach for new and innovative solutions that more effectively utilise the resources we have inherited from previous generations; with the obvious responsibility to our future generations. However, these solutions always need to be acceptable to governments, societies, local communities and the individual consumer, and fundamentally, need to be economically viable in addressing 21st Century needs. Therefore, this will entail a just distribution of the costs, risks and benefits of economic development. The question of 'environmental justice', relative to environmental degradation and social exclusion, is emerging as a subject with enormous resonance in global, national and regional debates over sustainability and is an issue that institutions from the UN to local authorities are increasingly engaging with to promote the objectives of sustainable development. As a concept, environmental justice is explicitly recognised at a policy level by the EU and UK Sustainable Development strategies and in law by key EU and international sustainability instruments such as the UN Rio Declaration, the Aarhus Convention and, via the principle of common but differentiated responsibilities in the UN Kyoto Protocol. It is now true that even in the short-term, serious reputational, financial and legal risks are being faced by those acting in an irresponsible way towards the environment. It is only through interdisciplinary research developed in a truly concurrent and collaborative enterprise context that research solutions can be demonstrated to be "theoretically valid", "environmentally friendly" and irrefutably "economically viable" in the sustainable future.

In closing these thoughts on the future direction of concurrent and collaborative enterprise engineering, served through the International Society for Productivity Enhancement (ISPE), it is encouraging to refer to the proposition expounded by McDonough and Braungart in their book 'Cradle to Cradle'. Essentially, that we need to rethink the way in which we make things in order to revise the 'Cradle to Grave' philosophy of the Industrial Revolution that is inconsistent with nature's principles and sustainable evolution; that human productivity and progress can be positively engineered and managed in harmony with the provision and needs of our natural environment, rather than sustainability being viewed as negative fixed constraints. McDonough and Braungart propose a new and fresh approach that provides an alternative route to utilising and enjoying the resources that nature has provided us, in exploring our future destiny in a more sustainable manner. One century on from the Industrial Revolution, this is now the time of the Sustainable Revolution; requiring holistic technological, process and integrated solutions to evolved socio-economic needs that are currently not well met in a sustainable manner. It might surprise Albert Einstein that he rather well encapsulated the nature of this evolutionary struggle when he stated: "The world will not evolve past its current state of crisis by using the same thinking that created the situation".

And so it is our great pleasure to welcome you to go through the Proceedings of the 15th ISPE International Conference on Concurrent Engineering (CE2008) hosted by Queens University Belfast in Bangor, Northern Ireland. Previous CE Conferences have been held in São José dos Campos, SP, Brazil (E2007); Antibes-Juan les Pins, France (CE2006); Dallas, Texas, USA (CE2005); Beijing, China (CE2004); Madeira Island, Portugal (CE2003) ; Cranfield, UK (CE2002) ; Anaheim, USA (CE2001) ; Lyon, France (CE2000) ; Bath, UK (CE99) ; Tokyo, Japan (CE98) ; Rochester, USA (CE97); Toronto, Canada (CE96); McLean, USA (CE95); and Pittsburgh, USA (CE94). The CE Conference series is organized annually by the International Society for Productivity Enhancement (http://www.ispe-org.net) and constitutes an important forum for international scientific exchange on concurrent and collaborative enterprise engineering. These international conferences attract a significant number of researchers, industrialists and students, as well as government representatives, who are interested in the recent advances in concurrent engineering research and applications. Concurrent engineering is a well recognized engineering approach for productivity enhancement that anticipates all product life cycle process requirements at an early stage in the product development and seeks to architect product and processes in a simultaneous and integrated manner. Therefore, it is fitting that this year the CE Conference Series considers “Product and Service Life Cycle Management for a Sustainable World” following on from last year’s focus on “Complex Systems Concurrent Engineering: Collaboration, Technology Innovation and Sustainability”.

You are invited to consider all of the contributions made by this year’s participants through the presentation of CE2008 papers collated into this Book of Proceedings, in the hope that you will be further inspired in your work in achieving Product and Service Life Cycle Management for a Sustainable World.

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Contents

Collaborative Engineering

Distributed Collaborative Layout Design in Service-Oriented Architecture

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Abstract. Current computer-aided layout design systems only support layout state generation, which is not ideal for engineering layout design based on distributed knowledge and intelligent environment. This paper proposes a system framework to enable distributed engineering layout design in service-oriented architecture. A federated layout design system based on Service-ORiented Computing EnviRonment (SORCER) implements the framework. In order to supply design services to users, distributed design resources and design tools can be wrapped as SORCER service providers. And the users should be wrapped as service requestors so that they can join in the federated layout design system. A layout design interface protocol is developed to define standardized design services for whole layout process. The protocol content include standard layout components and containers representation, design parameter, layout state representation, design constrain representation and human-computer interaction command etc. Data interoperability between services is enhanced by design context communication. In order to be free loaded and used in the federated layout design system, each service needs to implements the interface protocol strictly. This system aims to enable asynchronous distributed collaborative design with ease of alternative design services, reduced design cycles, and improved layout resolution quality.

Keywords. Distributed collaborative design, Service-oriented architecture, Layout, Layout design interface protocol

1 Introduction

With the recent occurrence of collaborative complex product layout design among designers, manufacturers, suppliers and vendors is one of the keys for designers to improve product design quality, reduce cost, and shorten design cycle in today's global competition. Distributed intelligent resources participate in layout approach

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development, layout components modelling, design decision making and share product information across local boundaries in an Internet-enabled distributed environment.

Current, some researches for automatic engineering layout design can generate good layout resolution [1-2], and some integrative computer-aided layout design (CALD) system support whole engineering layout design process [5]. But compared to traditional stand-alone CALD system, there are new issues that need to be resolved in distributed collaborative CALD system based on service-oriented architecture (SOA). For example,

(1) Design service provider and service requestor: design resources, design knowledge and design tools should be wrapped as service providers or service requestors, so that they can work in distributed computing environment based on SOA.
(2) Service registry, service lookup and service proxy.
(3) Service management.
(4) System security.
(5) Layout Design Interface Protocol (LDIP): each layout design service and service requestor need to implement the LDIP, so that they can join in the environment with loose coupling.

Due to Service-ORiented Computing EnviRonment (SORCER)[6-8] can deal with most of issues abovementioned, we build our federated layout design system (FLDS) on top of SORCER platform. A LDIP was developed for services in our system.

2 Framework of FLDS based on SORCER

SORCER is a federated service-to-service metacomputing environment that treats service providers as network objects with well-defined semantics of a federated service object-oriented architecture [6].

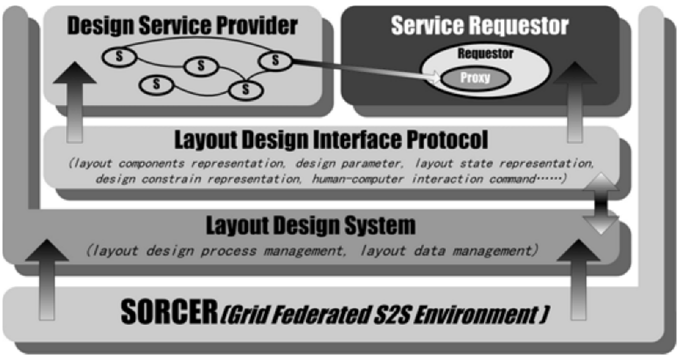

Figure 1. Framework of FLDS

Figure 1 illustrates the framework of FLDS. The design requestors should be wrapped as services so that they can join in the FLDS. A design proxy—net objects implementing the same LDIP as its service provider—always ready for calling by service requestors.

As shown in figure 2, the technology detail of service registry, service lookup and service employ will be hid by SORCER. The layer of layout design system only needs to deal with layout design services building, services management and design process control.

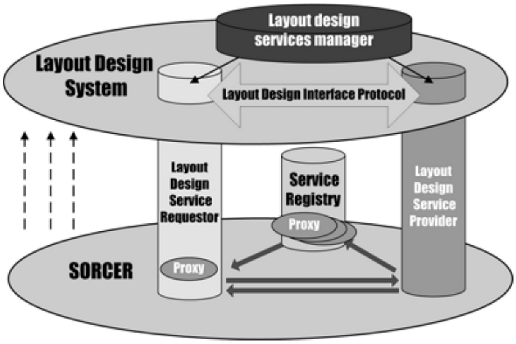

Figure 2. Layered platform of FLDS

The LDIP is fixed and known beforehand by the provider and requestor. Using our mechanism, a requestor can use this fixed protocol and a service description obtained from a service registry to create a proxy for binding to the design service provider and for remote communication over the fixed protocol.

3 Layout design interface protocol

LDIP play an importment role in FLDS. Each service should find match service provider according to the protocol. Both design data interoperability and design information commnication need implemention of this fixed protocol. In order to get same kind of service, A service requestor can employ different design service providers, which implement same LDIP.

The mainly content of this protocol include:

(1) Layout components and containers model format: a standard representation for 3-D layout components and containers modeling. If implemented this interface protocol, a general CAD system can supply layout components modeling service for FLDS as a service provider.

(2) Design parameter: a design service requestor can implement this interface protocol to submit user needs to FLDS.

(3) Layout state description: every service which wants to use layout resolution should implement this protocol. This interface protocol describes all information of layout result.

(4) Layout constrains model format: a standard representation for 3-D layout constrains modeling. A constrain modeling tool should implement this interface protocol to supply constrains modeling service to the FLDS.

(5) Algorithm interface: some algorithms which implement this interface can supply layout optimization service for the FLDS.

(6) Evaluation parameter structure: evaluation service should implement this interface protocol to supply evaluation service for FLDS.

(7) Human-computer interaction command: the command is used to operate some services with GUI in batch mode, for example: modeling command stream is used to build components model automatically on components modeling service.

(8) Multimedia report interface protocol: this protocol support to build a multimedia layout result report. A report service should to implement this interface for custom-built report generation.

The LDIP includes a mass of engineering layout design knowledge. Thus, more information and rules will be added into the protocol structure in the future. Figure 3 illustrates a demonstration of the layout components and containers model format abovementioned—a engine system modelling. This XML-based model format can be used in FLDS arbitrarily.

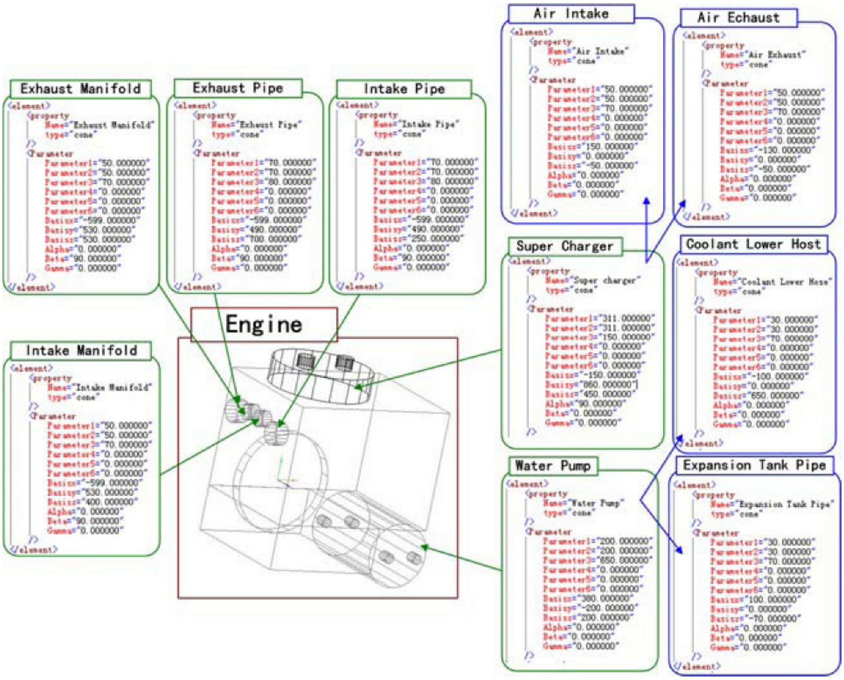

Figure 3. An engine modelling with standard layout components and containers model format

Due to powerful description ability of domain data, SORCER Context [6] and XML are good carrier for LDIP. SORCER Context is used as runtime communication carrier, and XML is employed to be data store format.

4 Implemention of FLDS based on SOA

FLDS builds on top of SORCER to introduce intelligent distributed collaborative design system. Whatever knowledge resources and intelligent resources can build their own service according to the LDIP, and launch the service to FLDS as a component. It is allowable that more than one service can implement same function in FLDS, and that's lead to services competition. The users or the service employer can choose the best service form all services with same function in FLDS. The "best" means best quality, best efficiency, or least cost etc.

4.1 Services structure of FLDS

Figure 4 illustrates that the hierachical services structure of FLDS. Users should play two roles in our system: service provider and service requestor. As service provider, a user should supply layout design requirement to other services in FLDS. To be a service requestor, a user can monitor the whole design process and get final layout design result. Every service are autonomous and can call other service in FLDS. The employer service don't need to care about what happend in employee services, even though the employee service calls other services either.

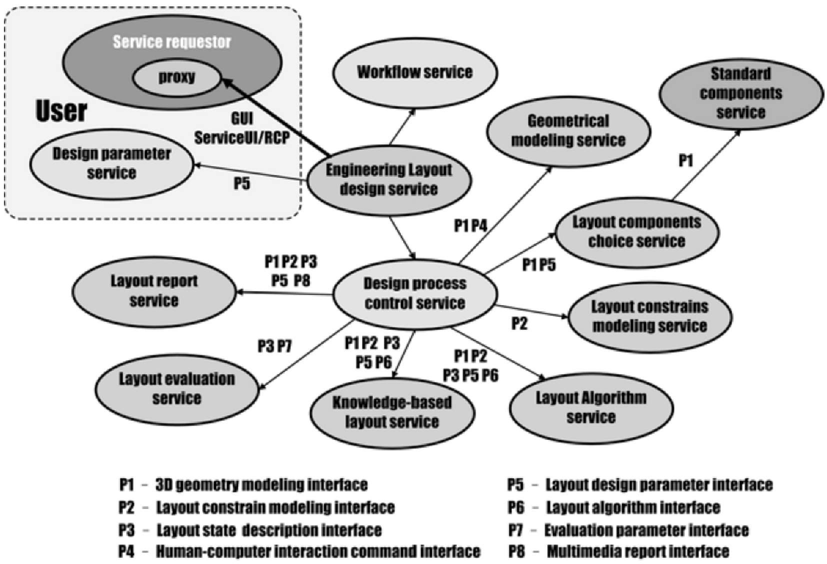

Figure 4. Hierarchical services structure of FLDS

As shown in figure 4, the engineering layout design service is an integrated service to supply whole layout design function. The user only needs to call engineering layout design service singly to start layout design process. Every call between services should follow matchable interface protocol.

4.2 Implemention of pivotal services of FLDS

A FLDS service must be a SORCER service first, and two ways are used to build a SORCER service: to wrap general software as SORCER services or to build SORCER applications directly. Figure 5 illustrates how to build a FLDS service from applications.

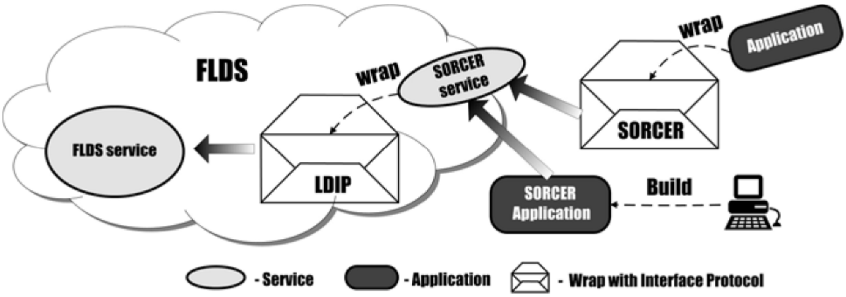

Figure 5. Build a FLDS service

Some pivotal design tools of FLDS were developed and the system was demonstrated through some real engineering application, as vehicle engine compartment layout design (As shown in figure 6).

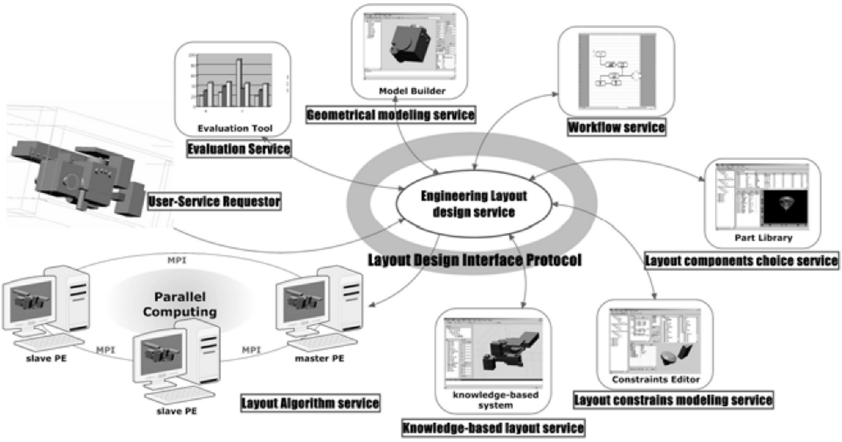

Figure 6. Pivotal services of FLDS

Not all of the services shown in figure 3 are necessary for an engineering layout design task. The users or designers can organize the services and add or delete them according their desire. As the example—vehicle engine compartment layout design (Shown in figure 6), the user employed layout evaluation service, knowledge-based layout service, layout algorithm service, layout constrains modeling service, layout components choice service, geometrical modeling service to deal with the task.

A service provider can supply Java-based GUI to service requestor for human-computer interaction. Some simple interaction can be wrapped as SORCER GUI, which can be loaded by Jini [4] service browser—IncaX [3] (As shown in figure 6). In this case, service users only need to run IncaX to call service GUI to get human-computer interaction. In contrast, complicated interaction application should be wrapped to Rich Client Program (RCP) (As knowledge-based layout service shown in figure 5), so that users must run integrated RCP to call the services what they want.

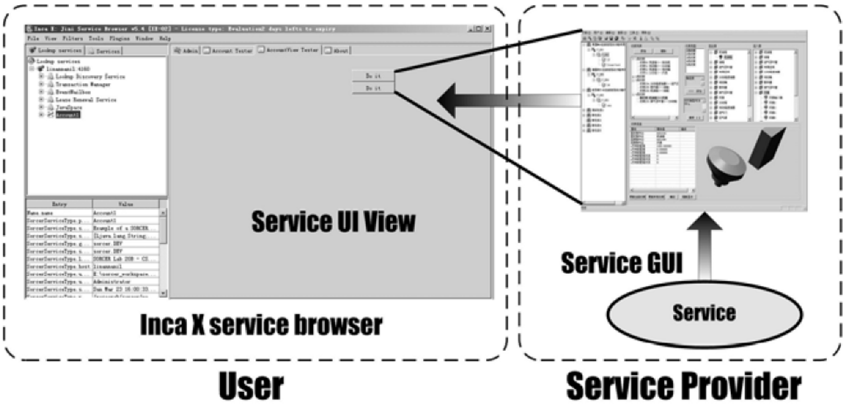

Figure 7. Jini service browser: Inca X

5 Conclusions

This paper presents a federated system for distributed collaborative engineering layout design in SOA to enhance automatic layout design ability. A layout design interface protocol is developed to define standardized design services for layout process. As a computing and metacomputing grid environment, SORCER was employed as bottom platform to build our FLDS—a highly flexible software system. Using FLDS and layout design interface protocol, engineer can arbitrary organize and manage the layout design services. The FLDS enable asynchronous distributed collaborative design with ease of alternative design services, reduced design cycles, and improved layout resolution quality.

With computation complexity and modeling complexity, engineering layout design problem needs to assemble more design resources to enhance design ability in the future.

6 Acknowledgement

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Resolving Collaborative Design Conflicts Through an Ontology-based Approach

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Abstract. This paper presents an ontology-based approach to resolve conflicts in collaborative design. In a collaborative design environment, achieving a global design of a product implies the proposed model is realisable and acceptable to all participants involved in the design project. Whenever this not happens we have a conflicting situation. The work presented here is based on the use of ontology modelling (OWL) to represent knowledge and, like that, to enable a reasoning process to be done. The results of this reasoning, the conflicting axioms detected, are used as starting point to a conflict resolution process. First, an automatic approach is tried. In case of failure, the next step is the direct interaction among the project participants, i.e., negotiation and mediation. A small electrical connector was taken as example to illustrate our approach.

Keywords. Collaborative design, conflicts, ontologies, constraints, negotiation, case-based reasoning

1 Introduction

Time and resources required to resolve conflicting situations in collaborative design have increased proportionally to the complexity of modern industrial systems. According to [14], even more, companies use geographically distributed knowledge, resources and equipment. The collaborative design process is typically expensive and time-consuming because strong interdependencies between design decisions make it difficult to converge on a single design that satisfies these dependencies and is acceptable to all participants [7]. Concurrent engineering brings new ways of organising design and manufacturing activities, introducing

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deep modifications, such as the concurrent realisation of product life cycle tasks. The collaborative approach also emphasizes the integration of all disciplines that contribute to the product development. The early-stage design is a very important part of this approach, as important decisions are made considering the entire project life cycle [6, 12].

Hence, conflict attenuation and resolution in early-stage design are essential points to be considered. Conflicts can be extremely resource hungry in terms of resources such as development time, budget and materials. Preventing them at this point – rather than later – is preferable, as it enhances the chances of success for consecutive design phases. This process involves identification and categorisation of conflicts and notification to the different involved parts, in order to put the situation under control as soon as possible [10]. When early conflict detecting is not possible, or not successful, a conflict resolution process must be undertaken.

This paper presents an approach for conflict resolution in collaborative design that takes into account the results obtained by an ontology-based conflict detection process [2, 3].

2 Conflict dealing in collaborative design

A lot of approaches have arisen to deal with conflicts in collaborative design. Among them, we chose to highlight the following ones: ontologies; thesaurus; prototyping; constraints checking; constraints relaxation; case-based reasoning; rule-based reasoning; priorities management; negotiation and mediation.

Ontologies and thesaurus are resources used to resolve linguistic conflicts. While the use of ontologies permits dealing with more complex conflicts; providing exact terminology is an accurate approach to mitigate meaning-based conflicts – the polysemic ones. So, for this kind of conflict a thesaurus is suitable [4].

Simulation tools are used to detect conflict inconsistencies [13]. Virtual prototypes permit the detection of structural-level interferences and simulators permit the evaluation of objects being used in the design. The use of these tools envisages detecting eventual conflicts [12].

Constraints are used to represent system's requirements, in order to enhance the collaboration process. Requirements are represented as groups of variables in spaces of feasible values. Such spaces improve efficiency through avoiding artificial conflicts, improving design flexibility, enhancing change management and assisting conflict resolution [9]. A constraint checking is an automatic task, taken to verify the consistency of a given model. Defined constraints may be relaxed during the negotiation process – if it is necessary – to facilitate the search for a solution.

Case-based reasoning is the process of solving new problems based on solutions for similar past problems. In this case, the most common past solutions are taken as starting point to solve the new problem [6].

Rule-based reasoning takes predefined rules / statements as parameters to check the given model. It is quite similar to constraint checking, except that the rules