Understanding Information Requirements in Product-service Systems Design

S. Kundu[1], A. McKay[1], P.G. Dawson[2]
[1]School of Mechanical Engineering, University of Leeds, Leeds, LS2 9JT, UK
[2]The Keyworth Institute, University of Leeds, Leeds, LS2 9JT, UK
mensk@leeds.ac.uk

Abstract

Service information is the information that is required to support the taking of decisions and actions in a service environment. In product-service systems (PSS) this information includes both information to support the lifecycles of physical products and associated services and information to support the management of services. Service blueprinting techniques have been used for visualising and mapping service activities. Effective delivery of service demands access to high quality service information (i.e. complete, correct, minimal and available to the right people at the right time). In this paper we extend the concept of the traditional service blueprint to include service information needed to deliver PSS. Three types of service information are considered: input information, process information and output information. The result is a Service Information Blueprint. In this paper we demonstrate, using a case study, how the service information blueprint is influenced by changes in service definition and contract type.

Keywords

Service Information, Service Blueprint, Information Requirements, Product-Service Systems, Computer-Aided Design

1 INTRODUCTION

In the move to product service systems, the delivery of engineering excellence demands the delivery of excellence in both physical products and associated through-life services. Emerging service products strive to deliver availability and capability to customers. As with physical products, the delivery of service excellence begins in the very early stages of the service lifecycle when contracts are developed and agreed. A key to the delivery of service excellence lies in defining contracts that are feasible and affordable for delivery. Once a contract has been agreed the service product is developed and then delivered. Access to high quality information (complete, correct, minimal and available to the right people at the right time in a form that they are able to use effectively) is key at each phase of service development and delivery: contract definition, service definition and service delivery.

This paper highlights the importance of service design representations including service information needed for the delivery of the product-service system. The concept of traditional service blueprint has been extended to introduce the concept of Service Information Blueprint. Section 2 provides a literature review on key tools and techniques for defining product-service systems. Section 3 focuses on service information requirements in product-service systems. Section 4 introduces the Service Information Blueprint model and a software prototype built on this model. Section 5 presents a case study on a coffee making machine repair service and applications of this case study data to the Service Information Blueprint model for availability type contract. Results from the research are presented in Section 6 and discussed in Section 7.

2 TOWARDS THE DEFINITION OF PRODUCT-SERVICE SYSTEMS

2.1 Definitions of physical products and service products

A product-service system is a system composed of a physical product and associated services that support the product through its life [1]. Current thinking on the dual nature of technical artefacts argues that technical artefacts have both designed physical structure and intended functional structure. On intended functional structures, Vermaas and Houkes, in their ICE (Intentionalist, Causal-role, Evolutionist) theory [2], assert that when engineers ascribe functions to artefacts they have to consider explicitly the goals for which agents use artefacts and the actions that constitute their use; the agents' actions are captured in a "use plan". A number of papers resulting from this work [3] include discussions on the distinction between function, behaviour and capacity of physical artefacts. The service element of a product-service system might be usefully regarded as a form of use-plan for the product; as such, it can be argued that product designers (when designing products for product service systems) need an awareness of the service requirements in addition to traditional usage requirements.

If services are regarded as products, or parts of product-service systems, then the following questions arise:

- What are the intended functional structures of service products and how might they be represented?
- How might product definitions for service products be formulated?

An initial analysis of product definition for goods and services is provided in Table 1.

2.2 Service definition tools and techniques

Over the years a number of tools and techniques have emerged for defining services that deal with complex systems. These are taken from the fields of social and behavioural sciences, business, design and information technology. They are often tailored to aid designers in a

Product (artefact – goods) definition	Product (service) definition parallels
Product definitions include data related to specification, definition, actuals [4], i.e., what is required, what has been designed and what was actually delivered.	There are differences in the detail of how the data is represented but the high level concepts of specification, definition and actuals appear relevant to services.
Product specification – requirements and links to stakeholder needs [5]	For services, Service Level Agreements seem to constitute a service specification.
Product definition – what is defined depends upon the kind of product and the Product Development Process being used, specifically, the information required at each stage gate and through key process steps	To understand parallels, we need to understand more about the Service Development Process. For ABB(Asea Brown Bovery) Full Services, this is the Full Service process phases (and decision points).
Actual products – these are the physical artefacts that are delivered to customers	A key difference between goods and services is that the "manufacture" and delivery of services are done at the same time, and services are transient.
Product definition/representation: structure and relationships to capture are key [6]	Product definition includes shape and constitution whereas service definition includes a process definition. The detail of this will form a part of the case study.

Table 1: Initial analysis of product definition for goods and services (reproduced from [1])

variety of ways throughout the service definition process in the projects they work on. Tassi [7, 8] presented a collection of these tools and techniques according to: (i) the design activities they are used for (e.g. envisioning, designing/co-designing, testing and prototyping, implementing); (ii) the kind of representation they produce (e.g. texts, graphs, narratives, models, games); (iii) the recipients they addressed to (e.g. stakeholders, professionals, service staff, users); and (iv) the contents of the project they can convey (e.g. context, system, offering, interaction). Further tools and techniques can be found in [9].

Service blueprinting approaches have traditionally been used to capture service-only products (e.g. services in hospitality and financial sectors). The research reported in this paper explored the application of the service blueprinting technique to define technical services associated with repair and maintenance activities (e.g. of a coffee making machine). Key aspects of a service blueprint are summarised below.

A service blueprint is built around the principal stages (i.e. key process steps) of the service and two axes: (i) a horizontal axis representing the chronology of actions conducted by the service customer and the service provider and (ii) a vertical axis that distinguishes between different areas of actions - these areas of actions are separated by different 'lines'. Each principal stage has its own service standards, scripts and guidelines which relate to the target performance levels of the service. The association of physical evidence with principal stages of the service addresses the intangibility of the service itself. Two kinds of process are associated with the principal stages: principal actions and support processes. Principal actions can be three types: onstage principal actions by the customer, onstage and backstage principal actions by the service provider's customer contact personnel. A service provider's principal actions and support processes interact with IT resources. For technical services these could include engineering information systems. The visibility of the sub-processes that form processes in the service definition is governed by their positioning on the blueprint relative to a number of visibility and interaction lines. If the enactment of a service blueprint is seen as a simultaneous production and consumption of the service then these lines govern who sees which parts of the delivery of the service.

3 INFORMATION REQUIREMENTS IN PRODUCT SERVICE SYSTEMS DESIGN

3.1 Service information

Information has been described as 'the lifeblood of the organization' [10] and 'the most valuable resource in industry today' [11] but it is also recognized that information is an often undervalued resource and difficult to manage. However, if properly managed, the value of information can grow over time. Information is important in service development and delivery as a means of enhancing decision-making processes. Information per se has no direct value but the impact of improved information quality can both reduce costs and enhance service performance. In the context of product servicing, information can provide details about the condition and usage of the product. In a service delivery context, on the other hand, information provides the contractual requirements of the customer to enable service delivery decisions to be made.

For this paper, service information refers to all the information that is required to support the taking of decisions and actions in a service environment. A service information system is a system (which may itself be a collection of systems) which provides the information required to take key decisions and actions in a service environment [12].

3.2 Service information requirements

Zeithaml et al. [13] identify five quality gaps in service delivery that may result in service failure. Recommended by Zeithaml et al. [13] and distilled by Lovelock and Wirtz [14] are a number of managerial strategies that should be taken to close the service quality gaps. Several of them are related to improving the management of service information. Effective delivery of service demands access to high quality service information (i.e. complete, correct, minimal and available to the right people at the right time).

McFarlane [15] asserts that the information requirements for support service solutions are multifaceted and highly dependent on the nature of the offering and the underpinning service agreement. Defining information requirements is perhaps the most neglected aspect of the information management process. Berkeley and Gupta [16] survey information required to deliver quality services involving high customer contacts. In high customer contact services, a firm's ability to deliver a quality service depends on its capacity to collect, process, distribute and use information. According to Berkeley and Gupta [16], service-delivery process can be broken down into input, process and output stages. They classify information required for delivering quality services into three broad categories: input information, process information and output information.

Input information refers to the information needed before the service is actually being delivered. This includes but is not limited to information related to: (i) identification of customer requirements and/or expectations; (ii) service provider's perception of customer requirements and/or expectations; (iii) definition of service specifications and standards; (iv) service definitions; (v) service history/records; (vi) demand and capacity planning; (vi) customer instructions. Process information is the information actually required by the service provider and the service recipient while the service is actually being delivered. This includes but is not limited to information related to: (i) knowledge to perform the service; (ii) job status; (iii) security and safety; and (iv) quality control/assurance.

Output information refers to information that is available after the service is delivered and as results of the service. Output information can be exploited for future use (e.g. as input information for the next cycle of service delivery, to judge the extent to which the service met customer expectations and needs or to inform the design of the next generation of services) [16]. This includes but is not limited to information related to: (i) internal quality measures; (ii) external quality measures; (iii) customer feedback (suggestions, complaints and compliments); (iv) service recovery; (v) service actually delivered; and (vi) changed state of the service recipient (as a result of the delivered service) [17].

A key aspect of product-service system lies in the need to support through-life product information. Kundu et al. [18] observe that the transition from product to product-service system delivery requires that engineering information systems change to meet new demands to support product data needed for the effective delivery of lifecycle services, including data generated through the whole life of the product, and the rationale behind decisions that were made through life. This is because over the extended time-span of a product's lifecycle, as opposed to its realisation, the people who created this information are increasingly likely to be unavailable to provide comparable support for the both service as well as physical product.

At each stage of the lifecycle of a complex engineering product, the needs of the various stakeholders involved are different and distinct. Designing, servicing, maintaining and upgrading a product are all knowledge intensive activities. Each of the different stakeholders (with different sub-problems and goals) in these stages has different knowledge requirements [19]. Also, since these stakeholders have a variety of information needs, it is likely that they would make different demands of a knowledge and information management system, such as Product Lifecycle Management (PLM) [19]. In order for knowledge management systems to provide efficient lifecycle support it is necessary to understand their knowledge requirements and the information flows between different stakeholders. McKay et al. [20] argue that the strategy of establishing future-proofed product information to support future lifecycle processes will fail in situations where the information requirements of the processes are not anticipated far enough in advance. To address this weakness, McKay et al. [20] propose an integrated product, process and rationale model that allows the definition of multiple product structures for a given artefact. The product structures can be created to suit the lifecycle stage and people (i.e. users) concerned. The inclusion of process, enterprise and rationale information allows the context within which information was created to be captured.

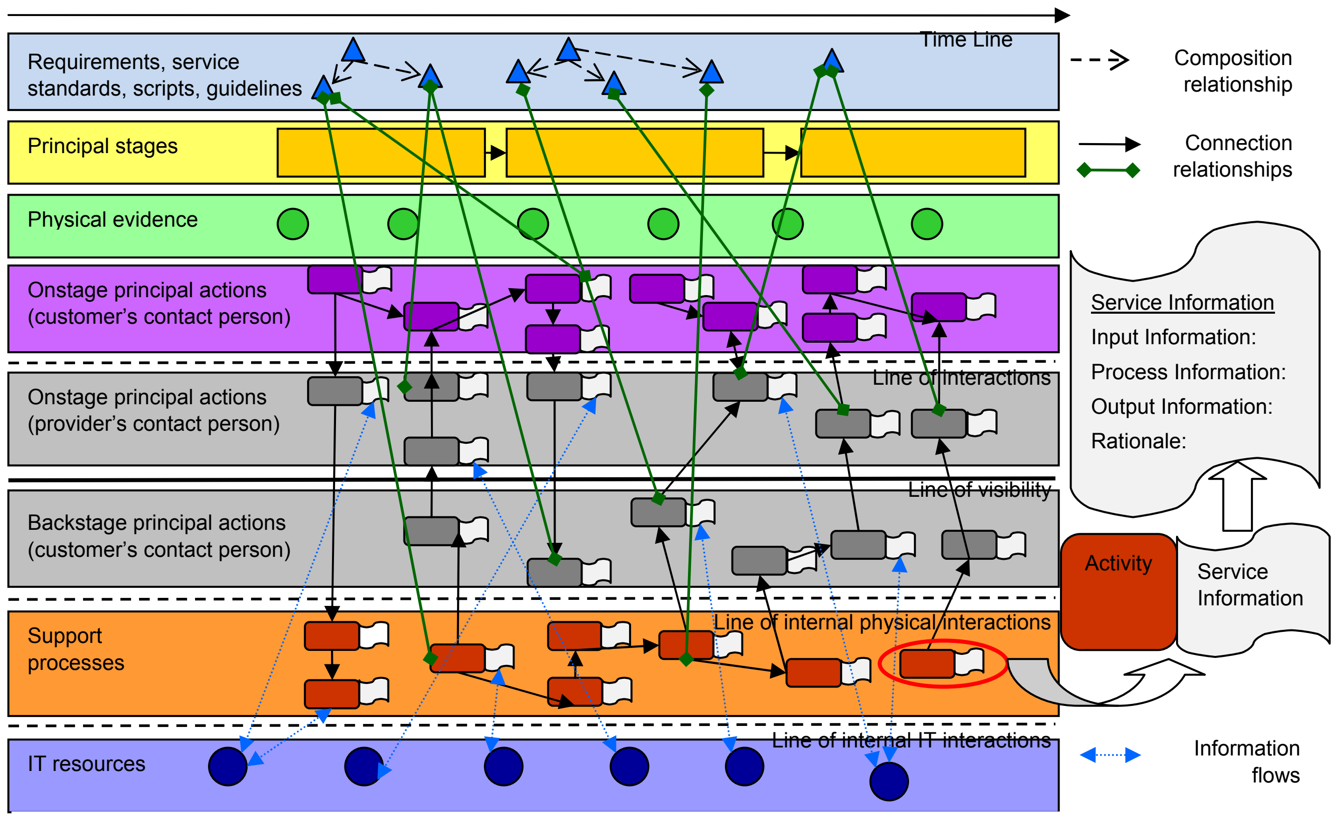

Figure 1: Key elements of a service information blueprint.

4 SERVICE INFORMATION BLUEPRINT

4.1 Service information blueprint

Product service systems (such as Rolls-Royce's 'Power by the Hour') are often designed and developed with aims to improve performance in a number of areas such as: reduce time, reduce cost, improve quality, improve responsiveness, and maintaining a sustainable business. Effective delivery of services with improved performance demands access to high quality service information (i.e. complete, correct, minimal and available to the right people at the right time). This is pertinent throughout the lifecycle (which typically include definition, development, delivery and evaluation) of the product-service system. To address this there is a need to capture service information requirements while defining services.

Service blueprinting techniques have been used for defining (basically visualising and mapping) services. This traditional framework of the service blueprint can be extended by including service information requirements for each service activities (done by the provider and customer to deliver the defined service) in the blueprint. The authors of this paper termed this resulting extended version of blueprint as 'Service Information Blueprint'. This is shown in Figure 1.

Scope: The Service Information Blueprint aims to support service designers in answering the questions: (i) What information is needed? (ii) Does the information exist? (iii) If so, where is it? (iv) If not, where might it come from?

Key Features: In the Service Information Blueprint, service information is categorised according to the swim lanes of the service blueprint: namely, 'requirements, service standards, scripts and guidelines', 'principal stages', 'physical evidence', 'onstage principal actions by the customer', 'onstage principal actions by the service provider's customer contact personnel', 'backstage principal actions by the provider's customer contact personnel', 'support processes', and 'IT resources'). The term and concept of 'swim lanes' have been adopted from the Business Process Modelling Notation (www.bpmn.org). However, the names, concepts and functionalities of all other key elements of the service blueprinting model remain the same.

For each of the service activities (done by the service provider and/or customer to deliver the defined service), three types of service information are considered: input information, process information and output information. This has been adopted from the service information classification scheme proposed by Berkeley and Gupta [16]. However, the definitions and concepts (of the input, process and output information) have been slightly changed and adapted to make them applicable for service activities (rather than the whole service which is composed of a collection of service activities or service process steps). For the Service Information Blueprint, input information refers to the information that are needed before actually performing or carrying out the service activity; process information is the information actually required by the actor while actually performing or carrying out the service activity; output information refers to information that is available after and results of a service activity is been carried out.

The Service Information Blueprint captures information associated with relationships:

- across the swim lanes of a service blueprint (e.g. between KPI-1 defined in the 'Service Standards, Scripts and Guidelines' swim lane and Activity2 of the 'Support Processes' swim lane); and
- between two elements within a swim lane of a service blueprint (e.g. between Activity1 and Activity2 of the 'Support Processes' swim lane). Relationships can be two types: connection and composition.

The Service Information Blueprint also captures or refers to rationale for any service activity definition or any defined relationship. In addition to capturing service information requirements, it also includes sources of that information or refers to that sources (if they already exist in external repositories).

4.2 The 'FSIB' software prototype

A software prototype, called 'FSIB', was developed based on the Service Information Blueprint model (proposed in Section 3.3 and depicted in Figure 1). In the FSIB, an instance of a service definition is termed as a service 'scenario'. In the FSIB, in a service definition 'scenario', the swim lanes of a blueprint are represented as 'canvases' or 'contexts'. The key elements in a swim lane are represented as nodes and arcs. The nodes represent: *definitions* in the 'Requirements, Service Standards, Scripts and Guidelines' swim lane; *stages* in the 'Principal Stages' swim lane; *descriptions* in the 'Physical Evidence' swim lane; *resources* in the 'IT Resources' swim lane; and *activities* in all other swim lanes capturing customer's and provider's activities. The arcs represent relationships among nodes within and across swim lanes. Relationships can be two types- connection and composition. The connection relationships are also classified to represent: materials flows or chronological sequences (in the arrow direction) or information flows or statements (for example to represent dependency links). In the FSIB, for each nodes service information requirements are captured in a separate dialog box. In this dialog box, service information (i.e. input information, process information, output information, and rationale information such as design rationale) for each service activity can be explicitly captured and/or implicitly referred to a hyperlink (if they already exist in external files or URLs or network addresses). A screen dump of the FSIB software prototype is depicted in Figure 2.

5 CASE STUDY – APPLICABILITY OF SERVICE INFORMATION BLUEPRINT TO COFFEE MAKER MAINTENANCE AND REPAIR SERVICE

The Service Information Blueprint model introduced in this paper was applied to a Coffee Maker maintenance and repair service case study (using the FSIB software prototype) for two types of contracts- availability type and spare only type. However, this paper reports in detail application of availability type contract only. The typical scenario is described below.

The Coffee Maker Manufacturer supplies Coffee Maker machines to its customer and takes responsibilities for their maintenance and repair in an availability type contract. The service level agreements (SLAs) and key performance indicators (KPIs) for the contact are as follows:

KPI 1: Call-to-Repair response time- 24 hours (max).

SLA 1: Provider to supply, install, maintain, repair and support spare parts and the whole machine.

SLA 2: Service package include planned preventive and predictive maintenance, and unplanned breakdown maintenance.

SLA 3: Provider is responsible for customer training and to show how to use the Coffee Maker.

SLA 4: Provider to supply user manuals / training materials to the customer.

SLA 5: Customer to pay annual fixed price to the provider for availability of the product (Coffee Maker) and services.

SLA 6: The price includes both spares and services (i.e. complete availability and ready for use).

SLA 7: 24 months minimum contract period (which can be extended after end of the contract).

SLA 8: Services are provided both as-planned and on-demand basis for the duration of the contract.

The contract includes planned preventive and predictive maintenance twice a year by the service provider. Besides, whenever there is problem (i.e. breakdown) with the Coffee Maker, the customer contact (by telephone) the service provider and report about the problem, and also schedules an appointment for engineer's visit. The service engineer is expected to visit the customer within 24 hours of reporting the problem. The service engineer diagnoses the root cause for the problem and try to fix the problem onsite. If for any reasons, the problem cannot be fixed onsite and have to take the Coffee Maker out from the customer's premises, an alternative Coffee Maker is provided to the customer for temporary use. The faulty Coffee Maker is then repaired at Coffee Maker Manufacturer's repair workshops by its maintenance team. All other planned preventive and predictive maintenance might also done during this time if their schedules are near. During repair and maintenance services, the prime service provider (i.e. Coffee Maker Manufacturer) have to contact its suppliers for components and parts procurement and to receive sub-contracted services. After maintenance and repair, the service provider's call centre staffs contact the customer to make an appointment for returning the serviced Coffee Maker. On the scheduled date and time the Service engineer returns the serviced Coffee Maker to the customer and takes back standby Coffee Maker (provided for temporary use). Databases, IT systems and service records are regularly interacted, updated and maintained throughout the service delivery process.

Data from the aforementioned case study were applied to the Service Information Blueprint model using the FSIB

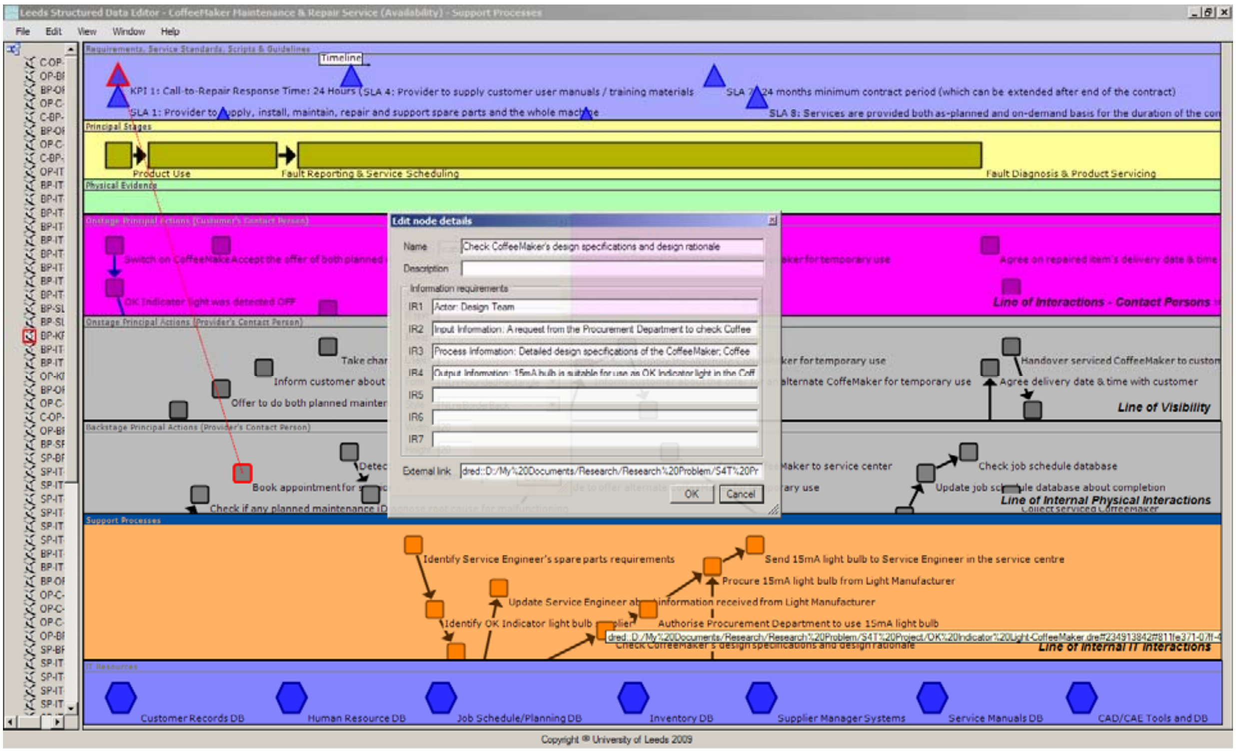

Figure 2: A screen dump of the FSIB software prototype showing results from the application of data for a Coffee Maker

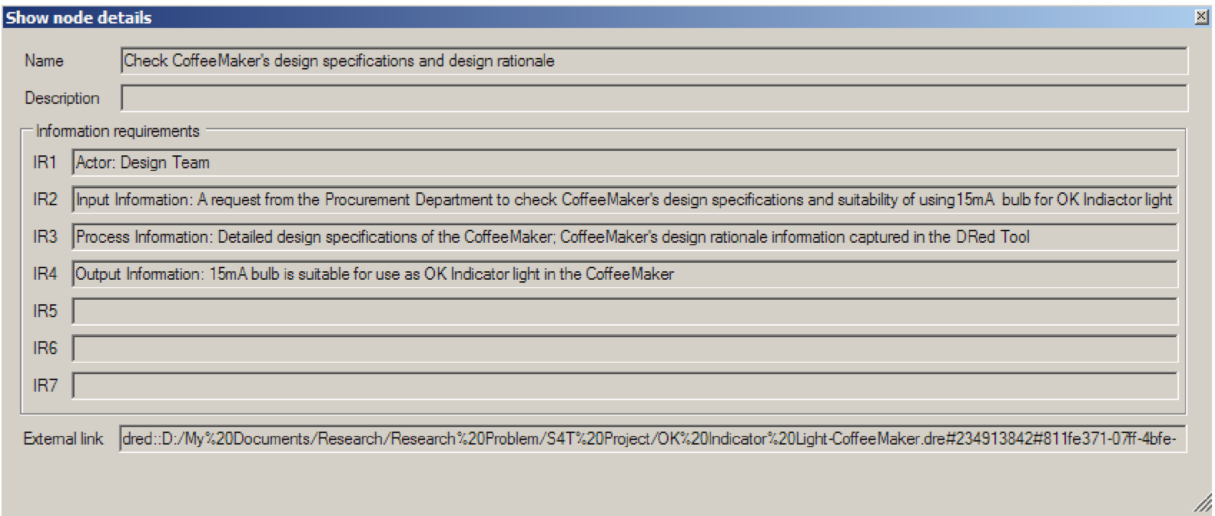

Figure 3: A screen dump showing how service information associated with a service activity is captured.

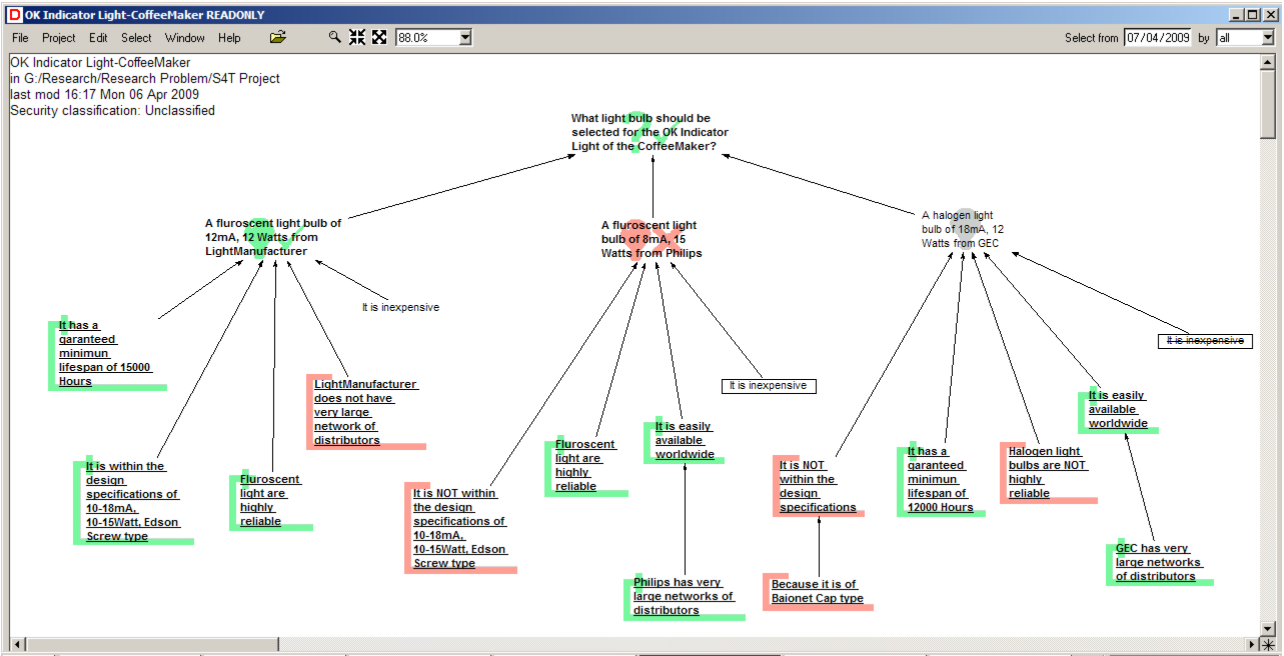

Figure 4: A screen dump showing design rationale information captured in a DRed [21] file.

software prototype. First the service scenario was defined by defining the key elements of each of the swim lanes and mapping relationships among these elements within and across swim lanes. Later, for each service activity, service information required for that activity and information resulted out of that activity were captured.

6 RESULTS

Data from the Coffee Maker machine maintenance and repair service in an availability type contract case study was applied to the FSIB software prototype. The key results are summarised in Figures 2, 3, 4 and 5. Figure 2 presents a snapshot of different swim lanes and their key elements (represented by nodes and relationships arrows/links). Service information required to carry out each service activity (done by either service provider or customer) were also captured in the FSIB software prototype. Figures 2 and 3 present an example of how service information associated with a service activity were captured in the FSIB software prototype. The 'External Link' field (shown in Figures 2 and 3) refers to design rationale information captured in an external DRed (Design Rationale Editor [21]) file. This is depicted in detail in Figure 4. The example in Figure 4 shows rationale behind selection of a 12mA/12W bulb for the Coffee Maker's OK Indictor light. For this case study, service information associated with each of the relationships (both within and across swim lanes) were also captured in the FSIB software prototype.

Figure 5 shows in an example how information associated with a relationship (represented by arrows/links in Figure 2) are captured. The red coloured link shown in Figure 2 is an example of a relationship between elements across swim lanes.

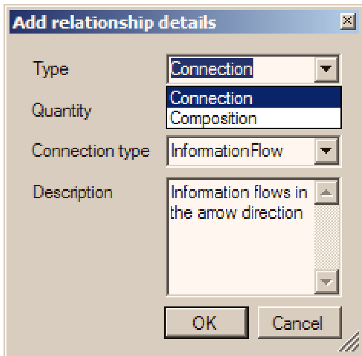

Figure 5: A screen dump showing how information associated with relationships are captured.

7 DISCUSSION

In this section, some key lessons are drawn out from the exploratory research reported in this paper.

Effective delivery of services with improved performance demands access to high quality service information (i.e. complete, correct, minimal and available to the right people at the right time). This is pertinent throughout the lifecycle of the product-service system. To address this there is a need to capture service information requirements while defining services. The Service Information Blueprint allows definition of service information requirements and capture of service information while defining services. It does so by categorising service information according to the swim lanes of the service blueprint. In activity swim lanes, it is important to define information requirements before and during the execution of a service activity. It is also important to capture any information that may result from a service activity as they might be useful in future. The Service Information Blueprint's ability to define accurate service information requirements and to include service information enables product-service system designers to provide improved service definitions.

It is essential to understand how elements within and across swim lanes of a service blueprint are related to each other. The Service Information Blueprint supports this by allowing service designers in defining relationships and capturing information associated with the relationships. One of the major outcomes of this capability of the Service Information Blueprint is the ability to link service activities (done by the service provider and/or customer to deliver the defined service) with the KPIs (Key Performance Indicators), PIs (Performance Indicators) and SLAs (Service Level Agreements) in the 'Requirements, Service Standards, Scripts and Guidelines' swim lane. A large proportion of a service is process/activity and the key feature that differentiates services from processes lies in the need to deliver the requirements of a contract. In the Service Information Blueprint, the relational links between service activities/processes and contractual requirements (such as KPIs, PIs and SLAs) show dependencies among them. For services (especially for contracted services), this means an ability to identify the service activities that need to be controlled in order to reach any particular target performance level (i.e. KPI or PI or SLA) of the contract.

In case the service information already exists in external sources or repositories, the Service Information Blueprint refers to the sources of that information. In the FSIB software prototype this is realised by including hyperlinks in the 'External Link' field. As demonstrated in the coffee making machine case study in Section 6, this external link could be a source capturing design rationale information such as DRed. Design rationale information is key in justifying design decisions or revisiting design decisions made before.

Ideas on service configuration can be drawn from a large body of work in product configuration. Product configuration involves linking physical elements together to form new products; part-whole relationships are used to define product breakdown structures and connection relationships are used to define how parts within a product breakdown structure relate to each other to deliver intended functionality. Different kinds of connection relationship occur in product breakdown structures: for example, mating conditions in assemblies and functional interactions in functional definitions. These ideas have been transferred for service products' definitions in the FSIB software prototype (or the Service Information Blueprint model that underpins the FSIB software prototype) because it is based on an underlying meta-model that treats physical and service products in similar ways.

In the Service Information Blueprint, in the service activity swim lanes, if the external links refer to other instances of service definition (or other instances of service 'Scenario' in the FSIB software prototype) in part-whole type relationships (or composition relationships), the Service Information Blueprint model can be used to define service breakdown structures. In service breakdown structures, such externally linked instances of service definition (or instances of service 'Scenario') are considered as part of the service definition (or the service 'Scenario') from where the links were made (as shown in Figure 6 below).

In the Service Information Blueprint (or in the FSIB software prototype), service elements can be reused within and across swim lanes. However, effective service configuration requires further understanding on how to (i) select service parts and (ii) connect them to each other to create new services that will behave in intended ways. Another key issue for successful service configuration is, given a service catalogue from which service elements can be selected, how will service parts be selected and re-used?

The ability to re-configure services becomes increasingly important when the service contract changes (for example, from availability to spare-only type and vice-versa, or availability to capability type and vice-versa). The Service Information Blueprint (and the FSIB software prototype) was also applied to the Coffee Maker maintenance and repair service in a spare-only type contract (not reported in this paper). It was observed that, with changes in contract type from availability type to spare-only type, some parts of the service definition for the availability type contract had to be changed whilst the other remained the same. With changes in contract type, KPIs (Key Performance Indicators), PIs (Performance Indicators) and SLAs (Service Level Agreements) also change. To reach these new sets of target performance levels, some of the service activities need to be re-defined and/or reconfigured and some new service activities need to be included in the service definition. With changes in service definition, service information requirements also change to meet new sets of target performance levels.

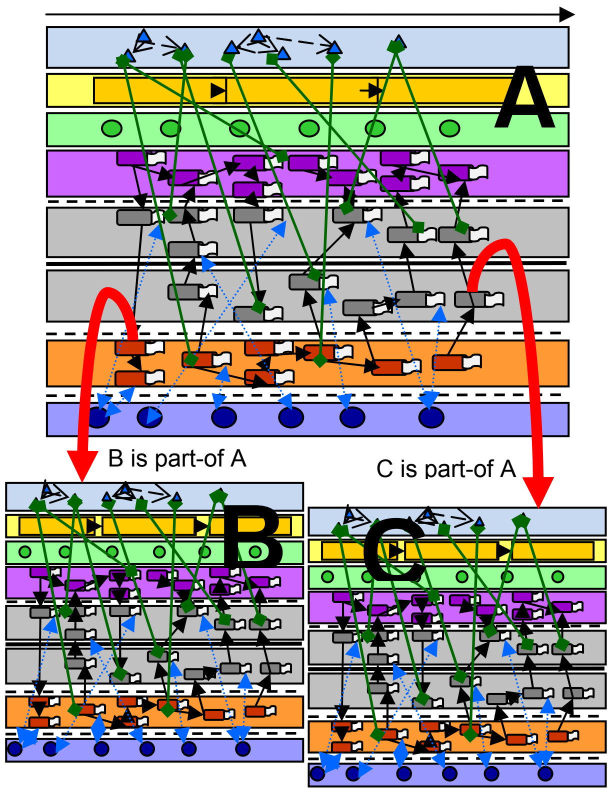

Figure 6: An example service breakdown structure.

8 CONCLUSION

Research reported in this paper provides insights for understanding the importance of service design representations, including service information requirements, in product-service system design. The paper introduced the Service Information Blueprint model and the FSIB software prototype and demonstrated their capability to define service information requirements and capture service information while defining services. The potential of the Service Information Blueprint model to define service breakdown structures was also explored. Early results indicate that the Service Information Blueprint model (and the FSIB software prototype) can support Bill-of-Materials type service breakdown structures. Future research will include development of tools and techniques to support service cataloguing and re-configurability.

9 ACKNOWLEDGMENTS

The research reported in this paper was carried out within Work Package 2 of the S4T project. The Support Service Solutions: Strategy and Transition (S4T) project is jointly funded by EPRSC and BAE SYSTEMS through Grant No. EP/F038526/1.

10 REFERENCES

[1] McKay, A., Kundu, S., and de Pennington, A., 2009, Supply Networks: An Approach to Designing an Extended Enterprise, Proceedings of the 6th International Conference on Product Lifecycle Management, PLM09, University of Bath, Bath, UK, 6-8 July.

[2] Vermaas, P. E., and Houkes, W., 2006, Technical Functions: A Drawbridge between the Intentional and Structural Natures of Technical Artefacts, Studies in History and Philosophy of Science, 37: 5-18.

[3] Kroes, P., and Meijers, A., 2006, Special Issue of Studies in History and Philosophy of Science on Dual Nature of Technical Artefacts, 37.

[4] McKay, A., Bloor, S., and de Pennington, A., 1996, A Framework for Product Data, IEEE transactions on knowledge and data engineering, 8: 825-838.

[5] Agouridas, V., Winand, H., Mckay, A., and de Pennington, A., 2006, Early Alignment of Design Requirements with Stakeholder Needs. Proceedings of the Institution of Mechanical Engineers: Part B-Journal of Engineering Manufacture, 220(9): 1483-1507.

[6] McKay, A., Hagger, D. N., Dement, C., and de Pennington, A., 2004, Relationships in Product Structures, in 7th Workshop on Product Structuring, Sweden, The Design Society.

[7] Tassi, R., 2009, Service Design Tools: Communication Methods Supporting Design Processes, URL: www.servicedesigntools.org, (accessed November 2009).

[8] Tassi, R., 2008, Design Della Comunicazione e Design Dei Servizi: Progetto Della Comunicazione Per la Fase di Implementazione (Communication Design and Service Design: Implementing Services through Communication Artifacts), Masters Thesis, Politecnico di Milano, Italy.

[9] Engine Group, 2009, Engine Service Design, URL: www.enginegroup.co.uk, (accessed November 2009).

[10] Scarrott, G. G., 1985, Information: The Lifeblood of Organization, The Computer Journal, 28(3): 203-205.

[11] Hollingum, G., and Jowell, R., 1978, Implementing an Information Strategy in Manufacture: A Practical Approach, Springer Verlag and IFS Publications Ltd, UK.

[12] McFarlane, D., and Cuthbert, R., 2008, Meeting Notes from WP2 Case Study Workshop, S4T WP2 Case Study Workshop, Farnborough, UK, 28 May.

[13] Zeithaml, V. A., Parasuraman, A., and Berry, L., 1990, Delivering Quality Service: Balancing Customer Perceptions and Expectations, The Free Press, New York.

[14] Lovelock, C., and Wirtz, J., 2007, Services Marketing: People, Technology, Strategy, 6th ed., Prentice Hall, Upper Saddle River, NJ, USA.

[15] McFarlane, D., 2007, Service Information Systems, DSI Workshop, Pittsburgh, PA, USA, May.

[16] Berkeley, B. J., and Gupta, A., 1995, Identifying the Information Requirements to Deliver Quality Service, International Journal of Service Industry Management, 6(5):16-35.

[17] Tomiyama, T., 2001, Service Engineering to Intensify Service Contents in Product Life Cycles, in Second International Symposium on Environmentally Conscious Design and Inverse Manufacturing, Tokyo, IEEE Computer Society, 613-618, CD-ROM.

[18] Kundu, S., McKay, A., de Pennington, A., Moss, N., and Chapman, N., 2007, Implications for Engineering Information Systems Design in the Product-service Paradigm, in Proceedings of the 14th CIRP Conference on Life Cycle Engineering: Advances in Life Cycle Engineering for Sustainable Manufacturing Businesses, Waseda University, Tokyo, Japan, Springer, Shozo Takata, Yasushi Umeda (editors), 11-13 June: 165-170.

[19] Eckert, C., Jowers, I., and Clarkson, J. P., 2007, Knowledge Requirements Over Long Product Lifecycles, in Proceedings of the 16th International Conference on Engineering Design (ICED'07), Paris, France, 28-31 August: 913-914.

[20] McKay, A., Kundu, S., Dawson, P. G., and de Pennington, A., 2009, An Integrated Product, Process and Rationale Model for the Provision of Through-life Information in Product-Service Systems, Proceedings of the 17th International Conference on Engineering Design, ICED'09, Stanford University, CA, USA, 24-27 August: 8-263-8-274, CD-ROM.

[21] Bracewell, R. H., Ahmed, S., and Wallace, K. M., 2004, DRED and Design Folders: A Way of Capturing, Storing and Passing on Knowledge Generated during Design Projects, in ASME Design Automation Conference, Salt lake City, Utah, USA, ASME.