A Reference Model for Improving an Inter-Organizational IT Management Tool

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***Abstract*—In recent years, the number of collaborations between IT service providers beyond national borders has been increasing tremendously. From the organizational point of view, all participants of such collaboration are independent domains. The participation of organizations in such collaborations is motivated by different factors. These factors include, but are not limited to, specialization on different technical domains, cost-optimization through usage of shared infrastructure and services, and regulation policies imposed by national laws. The IT service provisioning is always fostered by IT service management. In order to enable the collaborative service provisioning, the IT service management should be able to operate across organizational borders, including coordination of intra-domain activities. The capability to provide a holistic view of service infrastructures is one of the key factors that contribute to the success of an inter-domain collaboration. As a consequence, relevant information and events should be shared among the involved domains. In this paper, we present the use case driven tool I-SHARe as well as the theoretical framework inter-organizational (io) CMDB, both focused on the information sharing among collaborating organizations. The results of the I-SHARe pilot deployment in the pan-European collaboration Géant proves the necessity of such tools. Meanwhile, the evaluation of I-SHARe against requirements elaborated in the ioCMDB reference model identifies the tool's significant optimization and improvement potential.**

***Keywords* - IT Management, IT Service Provider Collaborations, CMDB, e-Infrastructures**

I. Introduction

In our previously published work [1] we discussed the necessity of developing an inter-organizational information exchange system using the Géant project as an example. Géant is a pan-European collaboration of over 30 national grade network providers, also known as National Research and Educational Networks (NRENs). Under this collaboration, NRENs provide the network infrastructures for international research projects such as the world's largest particle physics project, the Large Hadron Collider (LHC), located at CERN, or Grid collaborations such as Enabling Grids for E-sciencE (EGEE). The Géant collaboration offers networking services ranging from conventional IP connectivity with the best-effort connection quality up to dedicated optical End-to-End Links (E2E Links), which are provisioned to deal with data deluge that needs to be transported over networks.

Establishment of dedicated E2E Links per user requests often involves activities including planning, procurement, installation and configuration of the required network devices. In order to avoid deadlocks in such a rather complex process and guarantee the compatibility of involved devices, a tool support for the information sharing becomes a crucial influencing factor for a successful provisioning process. I-SHARe (Information Sharing across Heterogeneous Administrative Regions) is specifically designed and implemented to fulfill this purpose.

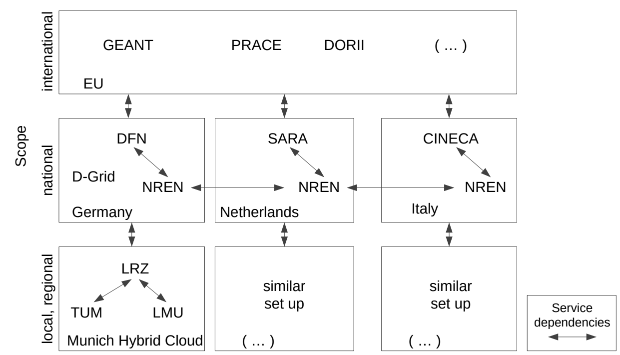

Fig. 1. Organizational scope of e-Infrastructure projects

As a successor to our previous work, in this paper we not only present the in-depth knowledge about I-SHARe, we also intend to provide a retrospective view and empirical experiences gained after its pilot operation. Most importantly, we systematically identify improvement potentials of the current version of I-SHARe for the future development. These could be regarded as improvements that are complementary to the user requests we received. The applied analytical methodology is based on the well-established design science [2]. Aligned with this method we introduce our problem field based on the actual observations of the tool aspects in the Géant case, for which I-SHARe is designed and implemented for a better support of IT service management. Although our discussion is conducted based on the Géant scenario, our findings are not restricted to this special use case. We see the possibility to reuse our results in other tools aiming to support inter-organizational IT service management (ioITSM) in collaborations. Potential application examples for further e-Infrastructure related projects are illustrated in Figure 1.

As shown in the figure, the institutional scope of the listed projects is divided into regional, national and international levels. The arrows indicate dependencies both within (e.g., NREN to NREN) and between the layers (e.g., Géant to DFN to LRZ). The Leibniz Supercomputing Centre (LRZ) for example is involved in e-Infrastructure projects on every level, like the Munich Hybrid Cloud environment on the local level with participation of the Munich universities (LMU, TUM), Grid projects (D-Grid) on the national or the Géant and PRACE project on the international level (see also [3][4]). In other countries similar institutional setups can be found. These listed projects have been previously strictly focused on operational aspects. With ever-increasing number of user base and scope, ioITSM issues become more compelling. Thus, a professionally operated IT service management with appropriate tool support is needed more than ever.

The rest of this paper is organized as follows: after giving a rather detailed discussion on a case study based on the Géant project in Section II, we outline our tool concept to assist ioITSM in Section III. This concept is mainly based on the results described in [5] and can be used as a reference model to either build a new tool from scratch or to evaluate existing tools according to their possible usage as an ioCMDB. We then discuss the latter aspect in Section IV. Our discussion mainly concentrates on a systematic analysis of an inter-organizational management approach developed in the Géant project. A brief survey on the related work is provided in Section V. We conclude this paper with a perspective for the future work in Section VI.

II. Case Study: I-SHARe in Géant

In this section we first outline the challenges by establishing and operating Géant network service *E2E Links*. Then we present an information sharing tool called *I-SHARe*, which is developed in the Géant project to support and coordinate manual handling processes of multi-domain E2E Links. We conclude this section with a discussion of experiences gained during the pilot operation with I-SHARe and our further development plan. The discussion provides the basis for the understanding of the challenges faced by the inter-organizational information sharing tools.

A. Géant Service E2E Links

The purpose of Géant is to interconnect NRENs and therefore to foster international research projects, in which participating organizations are connected through different NRENs. The portfolio of Géant includes various services among others conventional IP connections. However, such services cannot always fulfill all the challenging requirements of modern research collaborations. One of the most prominent examples of such a challenge is the Large Hadron Collider (LHC) project, which produces over 15 petabytes of raw experimental data per year [6] and related Worldwide LHC Computing Grid (WLCG) [7] built with the purpose of data processing and analyzing for the LHC experiment.

For a dependable and robust operation, such projects often rely on network connections with rigorous quality assurance. Realizing high-quality high-bandwidth connections in general purpose IP networks is a challenging task, many reasons can deteriorate network quality, for example communication flows can interfere with each other and lead to an inferior connection quality. In order to cope with user's challenging demands, a novel End-to-End (E2E) Link service has been introduced in Géant. E2E Links are dedicated optical point-to-point connections realized at ISO/OSI layers 1 and 2, with connection segments provided by one or more NRENs [8]. An E2E Link across multiple domains differentiates from its single domain counterpart in its quality requirements, variety on the participating networking technologies and geographical dimensions. E2E Links are multi-domain backbone connections, in which – in opposite to classical backbones – multiple network providers are involved and heterogeneous network technologies can be used. The E2E Link structure is presented in Figure 2 in principle.

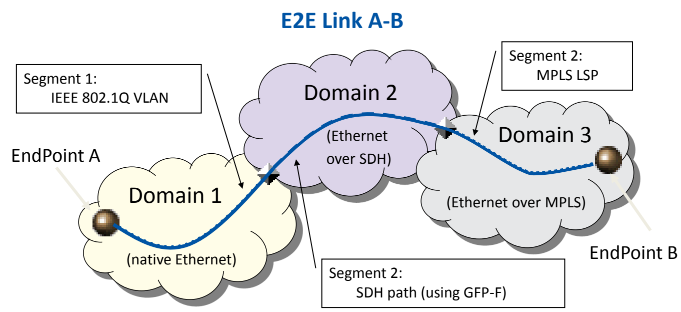

Fig. 2. Typical E2E Link Structure [9]

A main feature of a multi-domain E2E Link service is that a new connection can be requested and ordered independently from the actual availability status of required infrastructures. If a new infrastructure is needed to sustain the customer's request, it can be procured, installed, and configured according to the corresponding requirements of the new E2E Link. Consequently, all route planning procedures can only be done manually and require intensive interactions and task trackings between the involved NRENs.

Empirical experiences gained during the first years of the E2E Link service has revealed that exchanging and maintaining connectivity information determine the time efficiency of planning and installation of a particular E2E Link across domains. Information exchange via e-mail and planning via Excel sheets has proven to be error prone with a high probability of information losses or missing events, e.g., the delivery of the procured infrastructure by neighboring NRENs. This causes a high fluctuation on the time needed to plan and install new links. In order to improve this situation, a tool supporting the information exchange among participating NRENs was introduced for the E2E Links service.

B. Sharing Information with I-SHARe

The design and development of the *I-SHARe* tool has been performed by an international team of researchers working for different NRENs. I-SHARe covers information exchange for a complete life cycle of an E2E Link service instance, from its planning up to the decommissioning of the link.

Handling of single-domain and multi-domain information is clearly distinguished in I-SHARe at system architecture level (see Figure 3). Information such as operational groups and group members, their responsibility areas and contact data are handled in the *domain part* or in a NREN's domestic management tool. In both cases the single-domain information is propagated to I-SHARe via the *I-SHARe Domain Interface*. *I-SHARe Central Server* stores the copy of the provided information, so that it can be incorporated in the supported processes.

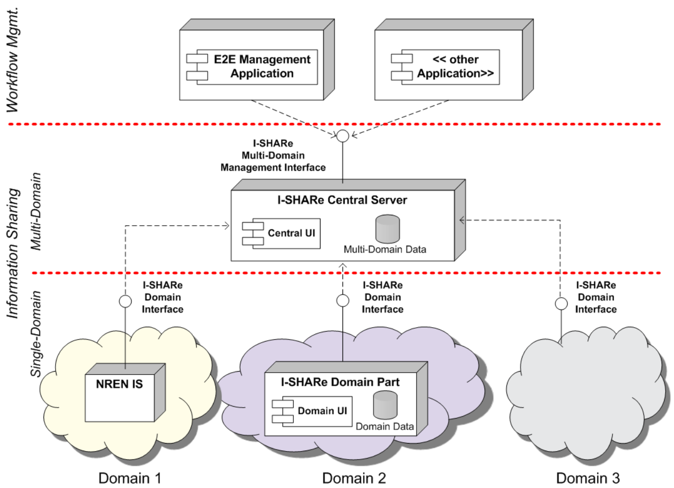

Fig. 3. System architecture of *I-SHARe* [10]

Multi-domain information like the route of an E2E Link through NRENs, interfaces of the adjacent connection parts provided by neighboring NRENs, and states of various operations are stored directly in the *I-SHARe Central Server*. This information can be accessed and edited via a web-based GUI.

All information stored in *I-SHARe Central Server* can be accessed from other applications through the *I-SHARe Multi-Domain Management Interface*. This interface is designated to facilitate the integration of I-SHARe with other tools, e.g., with other workflow management systems or analysis tools, so that relevant information regarding network connectivity can be reused and shared among different tools.

I-SHARe is designed to support the multi-domain manual management processes for a whole life cycle of E2E Links. According to specifications of the E2E Links service, one has to distinguish between four phases: (i) *Ordering* of a new E2E Link, (ii) *Setting up* of the ordered E2E Link, (iii) *Operation* of E2E Links in-service, and (iv) *Decommissioning* of no longer needed E2E Links. E2E Links in different phases can be accessed through different views (see top-level tabs in the GUI in Figure 4) of the *I-SHARe Central Server*.

Views on different phases of an E2E Link must be distinguished as the tasks in the corresponding phases require different knowledge, skills and competences, which are generally provided by different teams. Furthermore, the information

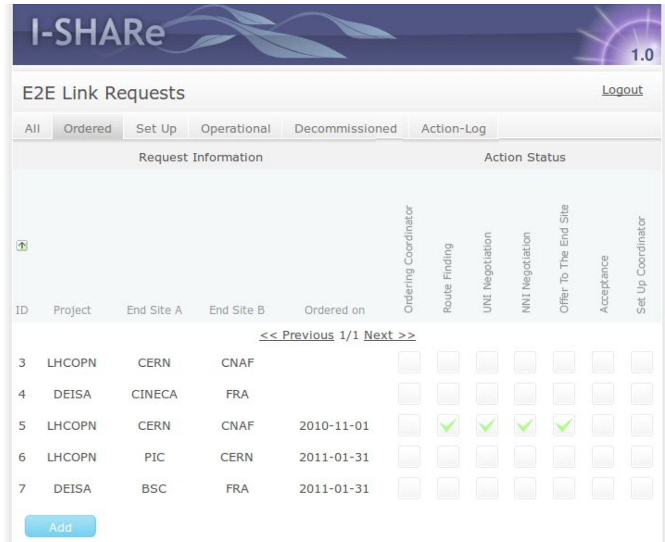

Fig. 4. I-SHARe's list of ordered links [11]

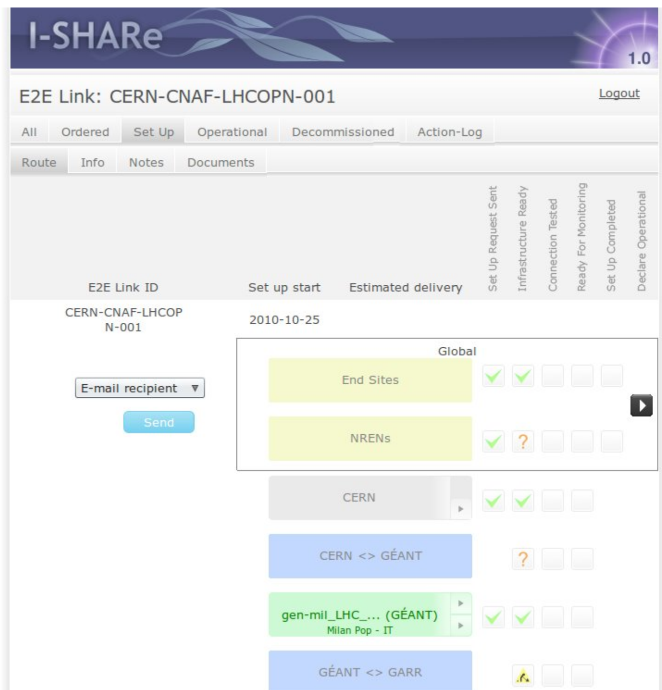

Fig. 5. Install and configure the network infrastructure [11]

needed in various phases are logically arranged in a sequential manner and overlap only partially. Therefore every view contains the list of E2E Links in the particular phase as well as set of status check boxes specific for the particular phase.

In the detailed view of a single E2E Link, only actions that are specific for the particular phase can be performed. For instance, during the ordering phase the E2E Link route through NRENs as well as interconnection points between NRENs (so called *Demarcation Points*, DPs) can be specified. During the installation phase this information can be refined with further details. For example the progress on – or difficulties of –

installation can be specified for every single interface (see Figure 5).

One of the most important advantages of I-SHARe is the possibility to coordinate efforts between NRENs. As all NRENs are independent organizations and often use hardware from different vendors and/or prefer different network technology, the compatibility of interconnected interfaces becomes one of the most critical factors.

Even if I-SHARe is designed as an information exchange rather than a workflow tool, however, some operation logic restrictions are already integrated. For instance, the button for declaring an E2E Link operational becomes enabled only after checkboxes of all involved interfaces are set to the state indicating that the setup is completed.

C. I-SHARe: Empirical Experiences and Future Plans

A detailed description of I-SHARe version 1.0 can be found in [1][10]. After the initial release in 2010, a user survery has been conducted among seleted NRENs during the pilot phase of operation. Feedbacks obtained from participating NRENs show a high acceptance of I-SHARe for its functionalities and usabilities. However, the survey also reveals several deficiencies that the users wish to be improved in the next version [12].

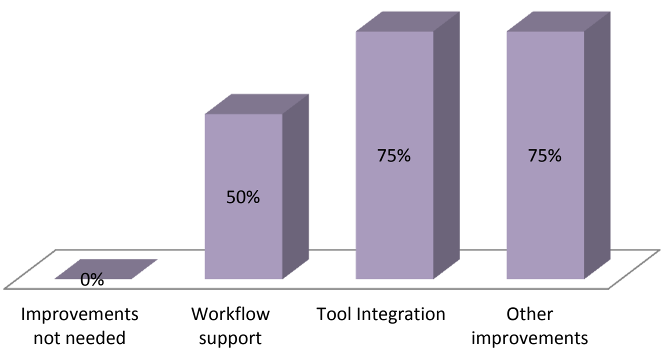

Fig. 6. Survey result on user requested improvements [12]

Among the requested I-SHARe improvements workflow support and tool integration are weighted as the most important feature (see Figure 6). As I-SHARe is a supporting tool, it should be flexible enough to sustain established workflows in the project. It also implies that the tool should be adaptive to changing workflows, which is a common case as shown by empirical experiences. For instance, during the time elapsed from the requirements analysis until the deployment of the tool in its pilot phase, the role model used in manual workflows has been changed. This change has introduced the necessity to change the role model implemented in I-SHARe.

Tool integration is a further critical issue that requires careful consideration. As I-SHARe supports manual processes, it should prevent users from the daunting tasks of re-entering same data in different tools. A technical solution for this problem is an extended communication interface. This interface should allow external tools to communicate with I-SHARe V2.0 in order to access existing or publish new data. For instance, it is planned that the E2E Link monitoring software *E2Emon* [13] will access the information about physical links from I-SHARe. In contrast, in the future it should be also possible to propagate the information about planned E2E Link segment maintenance from NREN-internal tools to the I-SHARe so that this information can be seen and considered in the multi-domain planning.

The pilot survey has also disclosed the necessity for several new features that were not identified during the initial requirements analysis process. For instance, in I-SHARe V2.0 a further communication capability should be implemented, so that stakeholders of a particular links can be automatically informed about the current status via e-mail notification in cases of network anomalies. This feature allowss I-SHARe to provide assistance to the manual management processes even if the network operators are not necessarily logged into the tool.

III. IOCMDB REFERENCE MODEL

Motivated by the aformentioned use case, there is a compelling need for a tool support of ioITSM. I-SHARe is designed and developed to address such needs. In order to systematically identify and formally derive improvement potentials of I-SHARe, in this section we apply a reference model of ioCMDB based on the concept discussed in [5]. This concept is fully in alignment to de-facto standards of ITSM, such as IT Infrastructure Library (ITIL, see: [14] and Section V). As suggested by ITIL, a Configuration Management Database (CMDB) acts as an information nexus to provide relevant management information to all disciplines of ITSM. The entities stored in a CMDB are Configuration Items (CI), which represent information about software, hardware, services, related documents and their corresponding interrelations. A readily available information repository as such will greatly improve the efficiency of IT management. Incident management, for example, uses specifications of CI priorities for the controlling of waiting queues, Change management is able to anticipate the impact of planed changes on potentially affected CI by having an overview of the CI relationships, and Availability management is able to identify the occurrence of single points of failures [15].

Whereas the conventional CMDB concept is well-studied and mature for IT services in a single organization, a comparative approach need to be elaborated and advised to take inter-organizational aspect into consideration. Our efforts toward this kind of approach is called inter-organizational CMDB (ioCMDB).

The applied research method is based on the principles of design science [2], which is a formal approach to build artifacts. Our claim is to create a reference model of an ioCMDB. As a reference model possesses both descriptive as well as prescriptive characteristics, the requirements identified within the design process in [5] will be used as a basis for the evaluation of I-SHARe. This evaluation will show whether I-SHARe is an appropriate tool to serve the purpose of

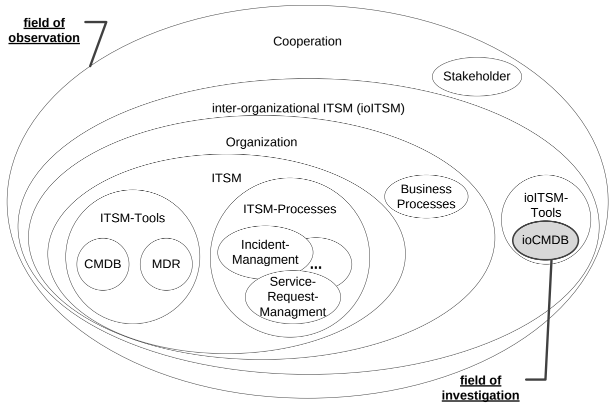

Fig. 7. Field of investigation and observation

information-sharing across the organizational boundaries. The more elaborated discussion is presented in Section IV. Note that, besides its critical role in building a new system complete from scratch, a reference model also prevails in evaluating an existing framework [16]. The initial step in our methodology is to define a frame of reference, in which a relationship between ioITSM and ITSM is intended to be established. Figure 7 illustrates a view on the fields of investigation and observation. As shown there, our investigation comprises all elements relevant for the designing goal of ioCMDB. The field of observation contains all related topics, which influence our investigation. Those include, e.g., relationships to other tools, ITSM processes, business processes, organizational set up, etc. The fundamental need for an ioCMDB is not limited to the problems as we demonstrated in the Géant case, we also observe the same problem area in similar structured IT service provider collaborations [3][17]. For an ioCMDB, a comprehensive list of requirements has been elaborated in [5]. All these requirements are structured according to the management architecture domains defined in [18] into information, organization, communication and functional model related requirements. In this way, all derived requirements are structured into manageable building blocks. A crucial input of this analysis is a set of ioITSM processes observed from various case studies and investigations, e.g., inter-organizational Fault or Change management [19][20].

In Section IV we demonstrate the usage of our ioCMDB reference model as a basis for evaluating the I-SHARe tool.

IV. Mapping between ioCMDB Requirements and I-SHARe

In our current work, we apply the elaborated ioCMDB requirements on the actual I-SHARe implementation. We summarize the results of the evaluation in a table form. For conciseness, we show here merely the evaluation results for a selected subset of the requirements. The results of the evaluation are presented on the right side of the column named "I-SHARe." Every evaluation entry consists of two ratings: on the left side of an arrow, the evaluation of the current implementation is presented; on the right side, the rating of I-SHARe after implementing planned changes is presented (see Section II-C for the description of planned changes). Thus, the rating scheme in the last column of the tables can be read as

$$[actual\ rating] \rightarrow [improved\ rating].$$

This comparison will also show, that not all potential aspects of optimization have been identified within the internal Géant evaluation itself. Therefore, the remaining gaps identified in this paper can then be used by the Géant project management as a foundation for the definition of a new I-SHARe development road map.

A. Information model related requirements

An essential prerequisite of IT service management is to have an overview of the entities being managed as well as their dependencies. Such information is necessary for assessing, e.g., the effects of future changes. These aspects are covered within an information model (IM). The IM enables a logical view on the IT infrastructure, even if this infrastructure is stretched over multiple domains. In Table I the results of the evaluation with respect to an IM of an ioCMDB are listed. A description of the foundation of our information modeling concept, which is based on established standards in the Business-to-Business (B2B) environment is outlined in [17].

Label	Requirement	I-SHARe
IM-1	Ability to model CIs	$0 \rightarrow +$
IM-2	Ability to model Interrelationships	$0 \rightarrow +$
IM-3	Ability to model dynamic information	$0 \rightarrow +$
IM-4	Ability to model meta data	$+ \rightarrow +$
IM-5	Ability of unique identification	$0 \rightarrow 0$
++ : fully covered, +: partly covered, 0: not covered at all -: irrelevant for this Scenario		

TABLE I
Requirements concerning information model

1) Evaluation of information model requirements: An important requirement an ioCMDB has to meet is its capability to model different classes of CIs and different types of interrelationships between these CIs. The IM for planning E2E network connection with quality assurance is shown in [21], in which specific CIs and their inter-relationships are described, e.g., `Domain`, `LinkProperties` or `CompoundLink`. In the current I-SHARe implementation such kind of entity information is predefined and hard coded. Thus, a corresponding Configuration Manager is not capable of defining new or alter existent CI types. Consequently if new types are requested the programmers have to extend them accordingly, build a new release of I-SHARe and make a roll out of this release in all participating organizations.

Another requirement concerning IM is the possibility to apply meta data, i.e., the data about the data. These can be distinguished according to [22] in the following functional areas:

- administrative, like data about the source information; in our case it would be the service access point of the

connected domain specific CMDB or rather any other Management Data Repository (MDR),
- descriptive, e.g., annotations by users,
- preservation, like data refreshing cycles,
- technical, as for example data related to how a system functions like it's software documentation,
- use, metadata related to the level and type of use of information resources, like log files.

In the actual I-SHARe release, meta data used for further description of extrinsic or intrinsic features of CIs like owner or status lifecycle are hard coded and thus, evaluated to 'partly applicable' in Table I.

2) Identified improvements in information modeling: The need for being flexible in defining dedicated CI classes has been identified as an action item to be implemented in the next release of I-SHARe. However, in contrast to our ioCMDB requirement for having an explicit role model, i.e., for the role of an inter-organizational Configuration Manager, any person is allowed to create CI types. As it is assumed presently that the tool is operated in a environment of dedicated services, currently such CI types are only representing the type interface. Thus, the evaluation remains on 'partly applicable'. According to our concept, a more dynamic modeling means must be implemented in I-SHARe to support various cross-organizational scenarios and services. In the actual improvement plan, the need for having meta data in place to improve the I-SHARe's operational capabilities is not recognized. This is the reason, for which the rating will remain the same for the next planned release cycle.

B. Organizational model related requirements

While IM addresses the modeling aspects of CIs and their relations, the focus of an organizational model (OM) lays on the governance structure. This is especially important for our intended use cases of cross-organizational provider collaborations. Thus, OM aspects have to be reflected in an ioCMDB. The requirements for a mapping of this structure as well as the adequate mapping of the user's roles are met to a high degree by the actual implementation of I-SHARe as can be seen in Table II.

Label	Requirement	I-SHARe
OM-1	Mapping of the governance structure	$+ \rightarrow +$
OM-2	Mapping of roles/users	$+ \rightarrow +$
++: fully covered, +: partly covered, 0: not covered at all -: irrelevant for this scenario		

TABLE II
REQUIREMENTS CONCERNING ORGANIZATIONAL MODEL

1) Evaluation of organizational model requirements: The governance structure within the actual I-SHARe release allows mapping users to groups and groups to roles. These roles are hard coded. Thus, this fact is rated as 'partly covered'. Due to organizational changes in such environments the corresponding governance structure might change as well. This aspect has not yet been addressed within the project.

2) Identified improvements in organizational model: The need for having roles in place for enabling a dedicated management of controlling issues has been identified also within the project itself. The actual release planning in the I-SHARe project is discussing the implementation of a transaction based role model. This will allow a transaction and role based logging, which again permits analyzing of log files. But here again, the role model itself will remain hard coded, and won't be changeable on a flexible base as suggested by our requirement catalogue.

C. Communication model related requirements

The mechanism, how management information are exchanged between the ioCMDB and related local CMDBs are subject of the communication model. In Table III the requirements concerning communication mechanism are shown.

1) Evaluation of communication model requirements: One important issue is the channels the exchanged messages of management information are taking. It is a requirement, that such channels can be specified according to the corresponding need. We will further describe the interaction characteristic in more detail in future work. At the moment, this requirement is not fulfilled completely by the actual I-SHARe release. This leads to the fact, that I-SHARe cannot support ioITSM processes efficiently. At present the requirement KM-2 for having web based communication means is fully covered by using e-mail and web services. Although, there is no way to define the communication characteristics as requested by requirement KM-4. Having a registry mechanism in place, where new or changed members or roles can be registered is of minor relevance for this scenario, since we are facing a stable organizational structure and its changes is the matter of long term planning.

Label	Requirement	I-SHARe
KM-1	registry	-
KM-2	web based communication	++
KM-3	define direction of communication	$0 \rightarrow ++$
KM-4	define communication mechanism	$0 \rightarrow +$
++: fully covered, +: partly covered, 0: not covered at all -: irrelevant for this scenario		

TABLE III
REQUIREMENTS CONCERNING COMMUNICATION MODEL

2) Identified improvements in communication modeling: According to the actual I-SHARe release planning, it is intended to send messages containing information about, e.g., state changes of inter-organizational relevant CI like the status of an E2E Link within the order process via e-mail to all participating members within Géant. The disadvantage of such a mechanism is a potential information flooding of all the recipients instead of informing only the affected responsible persons, resulting in rather ignoring such e-mails than reacting consequently.

Due to the requirements identified in [5] it should be possible to define both the direction of the communication and the mechanism, i.e., in case of state changes only the responsible roles should be informed via appropriate mechanism, which can be for example alerts or warning e-mails. The need for defining the communications directions, e.g., information provided by a local partner, that is propagated to I-SHARe and from there to relevant recipients in other organizations has also been identified as an open issue in the project. Thus, the introduction of roles should enable to support actions of the I-SHARe Domain Part, where an interface allows for the subscription of dedicated information with either push or pull mechanism. The need for having such subscription mechanism in place has also been recognized and is actually under discussion.

D. Functional model related requirements

Table IV outlines functional requirements a tool has to meet, if it is used as an ioCMDB. To assist ioITSM via an appropriate tool, it has to cover the lifecycle issues both of organizational as well as information related entities. Thus, the manipulation of roles and CI, the support of state changes of the cooperating partners, the possibility of adding, changing or deleting CI are vital aspects. Further, the users of the tool can have an easier insight at the management information, if there is appropriate visualization means offered.

These functional requirements are evaluated below.

Label	Requirement	I-SHARe
FN-2-2	manipulation of roles	0 → 0
FN-2-3-0	manipulation of configuration items	
FN-2-3-1	maintenance of configuration items	0 → ++
FN-2-5	visual representation of content	++
FN-2-6-1	data maintenance: transformation rules	0 → ++
FN-2-7	data maintenance: interfaces	+ → ++
++: fully covered, +: partly covered, 0: not covered at all -: irrelevant for this scenario		

TABLE IV
REQUIREMENTS CONCERNING FUNCTIONAL MODEL

1) Evaluation of functional model requirements: The current rating of the I-SHARe tool with respect to the functional model necessities can be seen in the Table IV. Examples of the I-SHARe information visualization are illustrated above (see Figures 4 or 5). The maintenance of configuration items itself, like adding new CI and their interrelations are implemented as quite complex procedures at the moment. Maintenance processes for filling in ioCMDB contents automatically are important in complex environments, since manual changes are leading to higher error rates and are raising the possibility of having not synchronized data pools. To update the contents in I-SHARe, no automatic updating mechanism between other tools like CMDBs from the participating members exist. Almost all data have to be maintained by hand. A CI that has been associated with a dedicated type of relationship can't be changed, once it has been introduced. In case, there would be automatic updating procedures in place, such procedures need to have a transformation mechanism in place resulting from autonomously defined data schemes of existent tools at the members' site. Such transformation rules are not covered at all by the actual I-SHARe implementation. One additional aspect is to identify the ownership of the data. This can be also part of visualization aspects [23]. Other Interfaces, as the ones for the e-mail based notification mechanisms, are currently not in place.

2) Identified improvements in functional model: The further release planning of the I-SHARe tool is addressing the need for having transformation rules in place. Then, an information model will be defined on a global level and all necessary transformations have to be implemented at the level of the member sites. This will change the future rating to 'fully covered'. The need for having better interfaces in place has been discovered. New releases will have interfaces, e.g., to monitoring tools and thus, the rating will be raised to 'fully covered'.

E. Nonfunctional requirements

Table V outlines an excerpt of non-functional requirements, i.e., all requirements concerning the operation and usage of the ioCMDB regarding the I-SHARe tool. A substantial need is to have access control and audit mechanisms in place to improve security issues, since the ioCMDB users are associated with the collaboration partners and acting in different roles. We have proposed an access control solution based on federated identity mechanism in [24]. Audit mechanism facilitates inspections resulting from compliance or regulatory requirements. By taking cultural considerations into account as for example different language versions or other dedicated cultural characteristics the user acceptance can be certainly improved.

Label	Requirement	I-SHARe
NF-4-1	security: access control	+ → +
NF-4-2	security: audit mechanism	+ → ++
NF-7	cultural requirements	0 → 0
++: fully applicable, +: partly applicable, 0: nonexistent		

TABLE V
NONFUNCTIONAL REQUIREMENTS

1) Evaluation of nonfunctional requirements: The actual state of access control in I-SHARe only allows authentication. Authorization means are missing and therefore, a rating to 'partly applicable' is justified. Since there is no authorization, audit mechanisms are used instead to be able to afterwards reconstruct performed transaction. Although Géant is an international project, no country specific characteristics, like different language or currency codes, have been introduced.

2) Identified improvements in nonfunctional modeling: In the near future access control mechanisms and cultural requirements are not planned for I-SHARe. Thus, the evaluation will remain on the same level. Cultural topics are considered of minor importance because all participants are expected to understand the English version of I-SHARe. The audit mechanisms have been undertaken an additional review process and will be improved both in structure as well as usability.

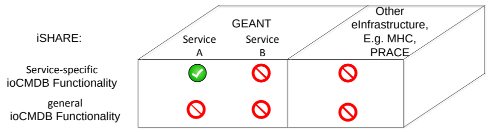

Fig. 8. As is portability of I-SHARe

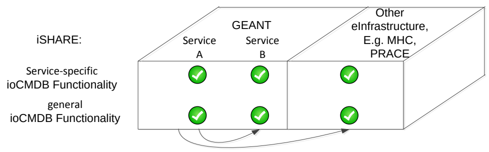

Fig. 9. To be portability of I-SHARe when adhering ioCMDB concept

F. Evaluation summary

In this section, we evaluated I-SHARe based on the requirements established for an ioCMDB. Further, we have considered the actual release planning of the I-SHARe. Despite its success in the pilot operation phase, there is still room for improvement observable for I-SHARe, as we showed and discussed in great details in this section. Such improvements will mainly affect scalability issues, as have been for example identified within the information model needs of having variable mechanisms of mapping new and changed types of CIs and relationships. The lack of having such mechanisms implemented leads to the fact that the actual I-SHARe is supporting the management of only a single type of service at the moment. Other ITSM related management processes have to be implemented separately.

Our evaluation shows that even if there have already been many desirable extensions identified in the Géant project, there is still potential for further improvement. Such improvement potentials need to be discovered and approached systematically. The actual usage spectrum of I-SHARe is shown in Figure 8. I-SHARe has been designed to support service and project specific purposes. Consequently, resulting in poor means of portability to manage other services as well and therefore, making it difficult to use it a) for other services respectively IT service management processes within the Géant project and b) for other similar structured projects, which have the same requirements. Indeed, there can be no synergy effects found to reuse this platform for ITSM related purposed within other e-Infrastructure projects as have been illustrated above.

If the concepts created in [5] will be used for further extension of the I-SHARe tool, a tremendously better portability can be established as can be seen in Figure 9. Consequently, this platform can be used to support cross-organizational IT Service management within other projects as well.

V. Related Work

Having introduced the reference model for the ioCMDB above, in this section, we now review some key researches, including existing frameworks, methods and models, which are relevant to our work.

Well-established frameworks exist in the realm of ITSM, one of the prominent examples is the IT Infrastructure Library (ITIL) [14]. In ITIL the concept of the Configuration Management Database (ITIL version 2) or Configuration Management System (ITIL version 3) has been introduced as an information platform supporting all other ITSM disciplines. Nevertheless, although there are some marginal descriptions concerning outsourcing relationships, ITIL itself does not consider the cross-institutional case in terms of collaborations between IT service providers. Furthermore, even if a CMDB should possess additional interfaces for tools from external suppliers, no available proposal concerning the design of such interfaces is currently known to us.

Other configuration management researches verify necessities of a new concept for an ioCMDB. The suggested information models for building up an intra-organizational CMDB are however not suitable for direct applications in real-world usages. CMDB tools currently applied in large scale intra-organizational environments do have – in the most cases – a focus on the visualization of monitoring aspects. Issues regarding global writing access to distribute data sources in a federated environment have not yet been fully covered [25]. Network specific CMDB tools that are capable to integrate data from different sources [26] are not directly applicable to our use cases, due to its lacking of considerations on the inter-organizational information models and functional requirements as we have identified.

A concept of CMDB federation (CMDBf) is proposed in [27]. The main focus of the suggested approach is on the integration of tools of different vendors (Management Data Repositories, MDR) into a single CMDB. To serve that purpose, a set of web-services are specified to facilitate data communication within a single organization. Concerning our requirements on the communication model, the suggested approach provides an useful reference and can be extended as a viable building block for the inter-organizational scenario. The extension should concentrate on implementing the CMDBf interface for all connected tools. According to the analysis in [28] the CMDBf will become a standard for heterogeneous CMDB integration and federation by the year 2013. But as it has been stated in [29] this standard only covers the data exchange aspect without specifying data types and their corresponding information models.

According to [30] the CMDBf is based on having a central management CMDB in place, it does not cover use-cases in cross-domain environments, e.g., in Cloud computing. Due to the fact that an universal access to any CMDB cannot be presumed in real-world IT operations, the authors propose a cross-organizational CMDB concept, in which a domain can expose individual CI information as RESTful web services. These resources can then be referred to and read by other domains in the context of service management processes. Nevertheless, this concept concentrates solely on communication related issues. Aspects of inter-organizational information modeling and a concept of authentication or authorization have not been considered.

In [31][32] concepts of federated or distributed databases are introduced. However, the design goal of ioCMDB is to assist the inter-organizational ITSM (ioITSM) processes and workflows. Despite its crucial role in ioCMDB, a distributed or rather federated database cannot be directly applied as one might expect it. Even if they share some similar characteristics such as distributed locations, autonomy and heterogeneity, however the access at database level to every connected CMDB or MDR still cannot be always presumed. Contrary to their approaches, dedicated interfaces between ioCMDB and CMDB or MDR must be implemented in our proposed solution. Instead of manipulating the contents of ioCMDB at databases level, our approach suggests to perform such alternations through specified functional areas, as we outline in Section IV-D. In this way, an alignment between ioCMDB contents and specifications of information models can be ensured.

Finally, data warehouse technique [33] has been applied as a viable approach to support complex analytical processes. Even though some commonalities can be identified between data warehouse and our use cases, e.g., analysis in incident or change management, however, data warehouse is optimized for read-only access. Modifying data at the global level and propagating such modifications to all connected participating CMDBs, as required by our scenario, are not well-supported by data warehouse.

VI. CONCLUSION

Recent proliferation of large scale IT-collaborations at a global level require highly efficient processes to cope with intricate tasks of infrastructure management. Whereas best-practice recommendations such as ITIL provide guidelines for designing management processes within a single organizational unit, more elaborations and research are needed to investigate issues regarding the management across multiple organizations. They not only differ in their geographical locations, they are also administratively independent entities, which exaggerate the difficulty to design and deploy efficient management processes. In fact, the management of infrastructures across organizational boundaries has not yet been fully understood and thoroughly investigated. To address this research issue, in this paper we discuss one of the fundamental elements that is designed to facilitate as well as to provide tool support for inter-organizational ITSM processes - *ioCMDB*.

Our discussion is motivated by an inter-organizational IT management scenario in the Géant project, which is a pan-European collaboration on high-performance networks as the e-Infrastructure to support international research cooperation in areas such as high-energy physics. To provide sufficient capacity for communication of data deluge generated by scientific experiments, dedicated E2E Links have to be provisioned across different organizations in order to transport huge amount of research data in a timely manner.

In this paper, we show the challenges of managing complete life cycle of such E2E Links across various management domains. To tackle such challenges, a management tool called I-SHARe is designed and developed for Géant specifically. The goal of I-SHARe is to provide a centralized repository of management information of links throughout their life-cycle. Any changes of a link, such as changes of routes, should be reflected accordingly and information must be updated in a timely manner. In our previous work, a holistic reference model is derived with the intention to generate new artifacts or evaluate an existing artifact. In this paper, however, we concentrate on the evaluation of the I-SHARe in accordance to the ioCMDB reference model. The ultimate goal of this work are manifold: on one hand, the ioCMDB generated reference model are applied as an auxiliary mean to identify the potential improvement opportunities to make I-SHARe a better tool for inter-organizational management; on the other hand, the practical aspect of an ioCMDB approach is put under tests in a real-world situation.

Through a careful evaluation and optimization, improvement opportunities for the current version of I-SHARe are identified consequently. As our future work, these achieved results will be reflected in the next version and will furthermore influence our future design of I-SHARe. With considerations of the identified improvement potentials, I-SHARe will gradually evolve into a tool that could serve generic inter-domain e-Infrastructure management purposes rather than being specially tailored for a set of rather limited use cases.

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