EA Management Patterns for Smart Networks

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Abstract: With the growing complexity of products and processes in a globalized market, companies are required to strive for a new quality of partnership. In Smart Networks, networking of partners goes beyond mere organizational networking, but involves also networking on the levels of knowledge and information/communication technology (ICT). The setup of ICT networking in newly formed Smart Networks requires not only information about already existing ICT infrastructure, but also a clear understanding of the organizational interconnections and knowledge interdependencies. This paper presents how the respective knowledge can be identified, visualized, and structured through information models in order to obtain decision support for the introduction of additional ICT support for the collaboration within a Smart Network.

1 Introduction

This article gives a short introduction on the management topic of *Smart Networks* and shows, how enterprise architecture (EA) management methods and patterns can be applied to this kind of networks – especially to its ICT parts. A Smart Network in this context is an organizational structure spanning different enterprises (manufacturers and service providers), which has been formed to pursue a business opportunity. A conjoint goal could e.g. be the collaborative manufacturing of products or collaborative innovation. Smart Networks are in their understanding of collaboration strongly oriented towards three constituting features as characterized by Filos [Fil06]:

Organizational networking refers to the strong interconnection of organizations in heterarchical structures and business processes, which are designed and optimized together.
Knowledge networking lays the base for organizational networking, by establishing effective exchange of knowledge. Each partner will have access to relevant knowledge for the different collaborative tasks to be performed at any time.

ICT networking supports virtual organizational structures and knowledge networking by providing the technical basis for transferring information objects, which form an explicit knowledge representation.

In comparison to *strategic networks* as described by Sydow [Syd92], Smart Networks are characterized by their high flexibility. They are able to adapt dynamically to changing business situations. According to the needs of the network from an *organizational*, *knowledge*, or *ICT* point of view, new partners can be easily integrated, key roles in the network may alter, or existing partners may be dismissed in order to reach the business opportunity driving the network. Actors in Smart Networks work together with high intensity and exchange relevant knowledge continuously. In this context, we speak about collaboration. Partners pursue not only conjoint goals but are performing actions together [SF07].

Research topic of DITF-MR are Smart Networks of small and medium-sized enterprises, which collaborate across industry sectors. For further examination, we assume, that partners are *equal*, meaning that none has a dominant role. Neither has any partner enough resources available to be the only driver for networking. Due to the lack of a leading role, such a network may be in need of a *mediator* or *coordinator* to facilitate collaboration.

Intended Audience
The idea of EA management patterns, as presented below, is to determine possible ICT support for knowledge-driven networks of equal organizations by introduction of additional software solutions, e.g. a collaboration platform. The focus of the patterns is on Smart Networks, and thus will be of special interest for mediators and coordinators of such networks. However, similar problems can be identified in any network with heterogeneous ICT solutions, and thus might be of interest for any coordinator of networked organizations. Through the explicit consideration of the intangible resource knowledge, the pattern will be especially suited for any knowledge-related ICT infrastructure.

2 ICT Network Managment for Smart Networks

This Methodology Pattern describes a business capability-driven methodology to plan the ICT infrastructure for knowledge exchange in a Smart Network.

2.1 Example

The European project AVALON is an integrated project, which focuses from a material point of view on new product and process developments using so-called shape memory alloys within textile structures. Several Smart Networks have evolved, which are targeting at different end-user applications of such materials. The final applications will be found in different industry branches – from medical devices to industry filters – while the production processes for intermediate products are textile processes. These cross-sectoral innovation processes need to be supported methodically and technologically, for which reason also collaborative innovation in Smart Networks is a major research topic in the project from a management point of view.

The AVALON Smart Networks need additional ICT support to facilitate knowledge exchange within the project. Knowledge exchange is required along the value-added chain

of each network, e.g. to communicate customer requirements or processing parameters. As well, it is necessary between Smart Networks to incorporate knowledge of the different service providers which may be applicable in several Smart Networks, e.g. to share insight in the relation between the chemical composition of the alloy and the resulting mechanical behaviour.

With respect to their existing ICT infrastructure, Smart Networks require both completely new functionalities for knowledge exchange and extensions of applications originally designed for company-internal use only. Within AVALON, the project coordinator DITF-MR decided to offer the Smart Networks a website and a wiki to share unstructured information and to provide various applications supporting innovation processes on the collaboration platform *efikton*®[1] to share structured information. Those applications comprise basic innovation management features for all of the project's Smart Networks and specifically designed applications to suffice the needs of selected networks, like risk management applications suited for the use in the industry sector of medical devices.

2.2 Context

A Smart Network consisting of a number of small- and medium-sized enterprises exists, for which ICT networking shall be improved. The set-up phase for a Smart Network is hence not considered in this pattern. Concerning the knowledge exchange in networks, three different knowledge access layers are distinguished [Reh07]:

Public knowledge, which is available to everyone (in- and outside of the Smart Network)
Community knowledge, which is available to the partners in the network
Internal knowledge, which is kept privately available to the respective owner or to very close collaborators only

In the context of establishing and improving the ICT networking, one has to be aware of which knowledge from the internal access layer has to be lifted to the community access layer in order to facilitate collaboration.

2.3 Problem

In order to facilitate collaboration within these Smart Networks, it has to be taken into account that we are talking about partners, which are in general locally dispersed. Collaboration on organizational and on knowledge level can therefore only be achieved through a high level of ICT networking.

The key question in this context is: **Which parts of the knowledge network should be supported by newly developed additional (ICT-)applications, and which parts might be left to decentralized, perhaps non-automated, communication means?** The following **forces** influence the solution:

Confidentiality Confidentiality and reliability concerns of the partners affect the complexity of the information exchange and may interfere with the demands of knowledge exchange.

Technology Different technologies and deviations from standards complicate the information exchange and thus influence implementation costs and time-to-operate.

[1] For more information see `http://www.diasfalisis.com/efikton`

Specified demands Clear specifications of which knowledge has to be exchanged facilitate the identification of necessary ICT support.

Implementation efforts Implementation costs and time are directly related to the confidentiality of information or the technologies to be integrated. Nevertheless, the economic factor is the most crucial point for many networks.

2.4 Solution

The solution to this problem follows a four-step approach. After focusing on understanding the organisational structure of the network, the knowledge exchange between network partners and the available ICT infrastructure of the network, it is possible to concentrate on supporting business processes and knowledge exchange with additional ICT applications.

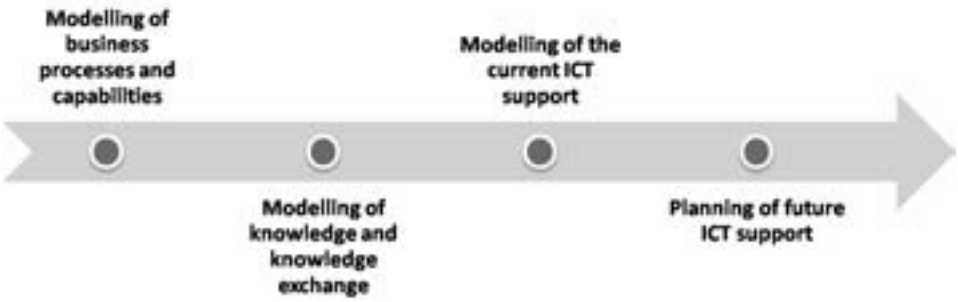

Figure 1: Process of the Methodology Pattern solution

Network partners are contributing to the conjoint business processes of the Smart Network by bringing in their core competences and business capabilities. The strength of the Smart Network as such is however not only the combination of several core competencies, but also the understanding of the organizational interdependencies as key issues for organizational networking. These *business processes and the respective business capabilities* of the partners have to be identified and modelled by *business architects* in a first step.

Through their orientation towards knowledge networking, the exchange of knowledge becomes another crucial factor in the activities of the Smart Network. *Necessary knowledge exchange* has to be identified and modelled by *knowledge architects* in order to enable effective collaboration between network partners. The identification of relevant knowledge can be supported by domain experts of the network partners, which are able to identify knowledge of all four different knowledge fields (topographical-organisational knowledge, processual knowledge, operational knowledge, infrastructural knowledge) [Reh07]. Additionally, it has to be analyzed through which knowledge access layer certain knowledge can be obtained at the moment and which knowledge therefore has to be transferred to a different access layer.

In a further step, the *current ICT support for the different business capabilities* is analyzed and modelled. Therefore, information on the different ICT systems installed and operated by the respective partners to support dedicated business processes is collected by *IT ar-*

chitects. The diversity of different systems used by the partners within networks of small and medium-sized enterprises is usually rather high, especially when these networks are stretching across different industry branches. Companies might use very specific software solutions or in-house developments. For that reason, parts of the analyses have to focus on the interfaces offered by the different systems to be considered.

In a last step, the *future information exchange* between the currently operating ICT systems is planned. During this step, e.g. the *relevance* of knowledge, *frequency* of knowledge exchange, the *complexity* of exchanged information, or the *number of partners* should be considered. This requires the involvement of all roles specified above. In order to reach an efficient use of collaborative applications, it also has to be considered that more specific applications might be more suited for the support of network activities. As the development of these applications demands much more resources, it has to be figured out very diligently which transactions require a support by specific applications, which ones could be provided with a generic solution, or which might not require an ICT approach.

Throughout the network, also exchange with similar structures of information might occur, which has to be taken into account. For the information exchange different ICT support scenarios can be considered (see also [Sch08]):

Manual peer-to-peer exchange This exchange type is the simplest form of possible exchange – no additional ICT means are employed in this context. It may use either standard means of communication like phone or e-mail, or can use the knowledge management concept of *Socialization* [NT95]. This type of exchange is suitable for *low frequency* and *bilateral* knowledge exchange demands. It may also be used for implicit knowledge, which cannot be easily transformed into explicit knowledge.

(Semi-)Automated peer-to-peer exchange This exchange type automates the direct exchange of information between two ICT systems using additional ICT means. This type of exchange is suited for high frequency of exchange, but requires very strict information structures and transformation rules. As each company uses its own information structure, this approach grows quickly in complexity with more partners to be included.

Exchange through a collaboration platform Using a hub-and-spokes infrastructure, a collaboration platform is suited especially when information shall be exchanged between several partners. It is possible to cope with different information structures and different frequencies of information exchange. Appropriate technologies allow the collaboration platform to represent the automatic peer-to-peer approach or to be used as a node, which is not storing copies of data redundantly, but which is limiting the view on heterogeneous data sources. While this approach may present an effective way to react to the flexibility of a Smart Network, the setup of such a platform and respective applications is demanding. With respect to limited resources available, either generic applications, which may not cover all needs of the different kinds of information exchange, are designed or only selected parts of the network can be supported with such applications.

2.5 Consequences

Using this Methodology Pattern will facilitate the setup of additional ICT support for Smart Networks. Through the systematic knowledge-oriented analysis of business pro-

cesses, the pattern yields specifications of required support for knowledge exchange. Confidentiality concerns and technology issues are part of the analysis and thus can be considered easily, so that the final implementation efforts can be significantly reduced. Applying this pattern helps also to choose the appropriate architecture to prepare knowledge for the different knowledge access layers. However, the application of the pattern itself is quite costly and thus has to be taken into account as well. One additional problem of this pattern is that ICT support will be introduced very early after the creation of such a network. In this phase, available infrastructural knowledge about necessary content and structure of possible knowledge exchange will be very limited. Therefore, this pattern depends much on the competencies of the knowledge domain experts and the accurateness of their estimations.

The pattern can be applied to any kind of Smart Network, independent of its size or the size of the acting organizations. It has to be considered that the number of partners, and also their competencies in the field of ICT applications and technologies, will affect the application of the pattern itself. The expected benefit may be less for smaller networks, but also the effort is signifcantly reduced. Thus, life-time of the Smart Network is the crucial criterion to figure out if the benefits justify the effort.

2.6 Known Uses

This pattern has been used by the team of DITF-MR in different integrated research projects concerned with Smart Networks, e.g. the aforementioned AVALON (see `www.avalon-eu.org`), Leapfrog (see `www.leapfrog-eu.org`) or contex-T (see `www.contex-t.eu`). The Smart Networks in these projects are all covering completely different value-added chains in different industry sectors. This pattern is also basis for the Smart Network Modelling method developed by DITF-MR.

2.7 See Also

The implementation of this pattern *ICT Network Managment for Smart Networks* can be supported using the Viewpoint Pattern *ICT Network Map* presented in Section 3.

3 ICT Network Map

This Viewpoint Pattern provides a way to visualize information about business capabilities, knowledge exchange, and ICT support with a Smart Network.

3.1 Example

The Smart Network in the AVALON project has been discussed and set up in preparation of the collaborative realization of a business opportunity. Additionally, the ICT systems, which support the respective business capabilities have been documented by each participating partner. Now the ICT support of the Smart Network shall be planned. In order to facilitate this planning process, an overview on the current support should be given.

3.2 Context

The pattern can visualize the ICT support for knowledge exchange in a Smart Network.

3.3 Problem

You want to visualize the ICT systems currently in use to support the business capabilities of the different partners in a Smart Network and relate them to the demands of knowledge exchange. The key question in this context is:

How do you visualize, which parts of the knowledge network should be supported by newly developed additional ICT-applications, and which parts might be left to decentralized, perhaps non-automated, communication means?

The following **forces** influence the solution:

Clear visualization How can you visualize the information in a concise manner?

Stakeholder acceptance How can you promote acceptance of the visualization as an explication of their demands and business capabilities by the partners?

3.4 Solution

A view (see Figure 2) according to the respective viewpoint is a two-dimensional map with an x-axis made up by the high-level business processes of the Smart Network. The y-axis complementingly enumerates the partners collaborating in the Smart Network. Additionally, mediators may be listed on the bottom end of the y-axis. The symbols on the axes partition the main area of the visualization in fields – these intersections are filled with a symbol representing a business capability, which expresses that the respective partner can provide support for the respective business process. On the level of the business capabilities, the knowledge exchange demands from the knowledge network are denoted as arrows connecting the source and target capability.

The currently deployed ICT systems used to support the business capabilities at the different partners are represented by rectangular symbols nested into the symbols representing the respective business capability. The ICT systems are connected with lines, if an information exchange takes place between these systems.

3.5 Variants

Variants of this Viewpoint Pattern exist, of which a prominent one omits the ICT network level details (business applications and information exchanges between them) and focuses on the knowledge network exclusively. The variant can easily be created using the *layering principle* of software cartography as presented in [Mat08]. This variant is similar to the *Topography Model* found in [FR04]. Another variant could use different types of lines between the ICT systems to indicate the level of automation for the specific information exchange.

3.6 Known Uses

Visualizations according to a similar viewpoint have been used by DITF-MR researchers in the different aforementioned projects, e.g. the AVALON project.

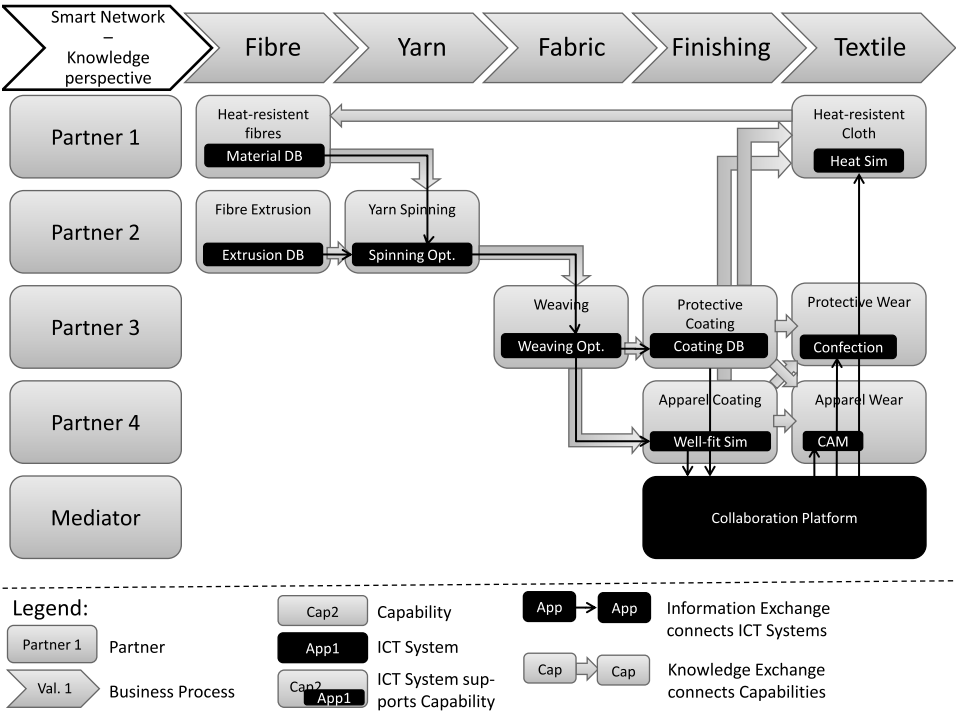

Figure 2: Exemplary view for Viewpoint Pattern ICT Network Map

3.7 Consequences

The ICT Network Map becomes unusable, if too many exchange flows should be shown. In such a case split the diagram along the x-axis. This may nevertheless affect the perception of the knowledge exchange demands negatively, as the information is hence distributed on two visualizations. Splitting the visualization along the y-axis might be also an option to reduce information density, although the stakeholder acceptance might be negatively influenced, if a partner does not find himself on all of the visualizations.

3.8 See Also

The Viewpoint Pattern *ICT Network Map* is based on information stored according to Information Model Pattern *ICT Network Support* presented in Section 4 and can support the methodology of Methodology Pattern *ICT Network Managment for Smart Networks* (see Section 2).

4 ICT Network Support

This Information Model Pattern provides a way to store information about business capabilities, knowledge exchange, and ICT support within a Smart Network.

4.1 Example

The knowledge network of the Smart Network in the AVALON project has been documented in a respective model. Additionally, the partners have supplied information on the ICT systems, which are used to support their business capabilities. Now the ICT support of the Smart Network shall be planned.

4.2 Context

Available knowledge within the Smart Network is described via *business capabilities*, which are contributed by the respective *partner* as support for specific *business processes*. Additionally, the documentation of these business capabilities should be extended with information on the knowledge exchange (and knowledge access layer), which has to take place between the collaborating partners. Complementing the knowledge level model of the Smart Network, the ICT support for the network has to be planned, especially taking into account the knowledge exchange demands as incorporated in the knowledge network.

4.3 Problem

You want to get an overview on the knowledge network constituing your Smart Network, in order to prepare decisions on the ICT network for supporting the knowledge exchange. The key question is: **What is a good way to store and maintain information about business capabilities supplied by the Smart Network partners together with information on the needed knowledge exchange?**

4.4 Solution

The needed information can be stored in an information model employing the classes depicted in Figure 3. These classes and the relationships between them are detailed below:

BusinessCapability A business capability refers to the ability of certain partners to execute a respective business process of the collaborative value chain.

BusinessCapability isSourceOf KnowledgeExchange respectively **BusinessCapability isTargetOf KnowledgeExchange** These relationships are used to describe, that a knowledge exchange takes place connecting certain business capabilities.

BusinessCapability relatesTo BusinessProcess A business capability supports the execution of a respective business process.

BusinessProcess A business process describes a high-level process concept for collaborative activities. The business processes, which are considered in this pattern, form a linear order and are supported by one or more partners in the Smart Network.

CollaborationPlatform A collaboration platform is the contribution of a mediator to the Smart Network supporting hub-and-spoke information exchange complementing the direct, i.e. peer-to-peer, exchange.

ICTSystem An ICT system represents a deployed instance of a software system facilitating information processing and communication.

ICTSystem contributesTo BusinessCapability The respective ICT system is used by the partner as part of the ICT support for the referenced business capability.

ICTSystem isSourceOf InformationExchange respectively **ICTSystem isTargetOf InformationExchange** These relationships describe, that an information exchange takes place between two ICT systems.

InformationExchange An information exchange represents an actual flow of serialized information between two ICT systems.

InformationExchange implements KnowledgeExchange One or more information exchanges can be used to actually realize the knowledge exchange demands.

InformationExchange executedVia CollaborationPlatform An information exchange can be direct, thus not having a collaboration platform assigned, or indirect (mediated) by a reference collaboration platform.

KnowledgeExchange A knowledge exchange represents the need to exchange knowledge during the collaborative execution of business processes in the value chain. It is assigned attributes for indicating its **complexity** and **frequency** respectively.

Partner A partner is a company contributing support for one or more business processes in the Smart Network.

Partner contributes BusinessCapability A partner contributes a respective capability to the Smart Network.

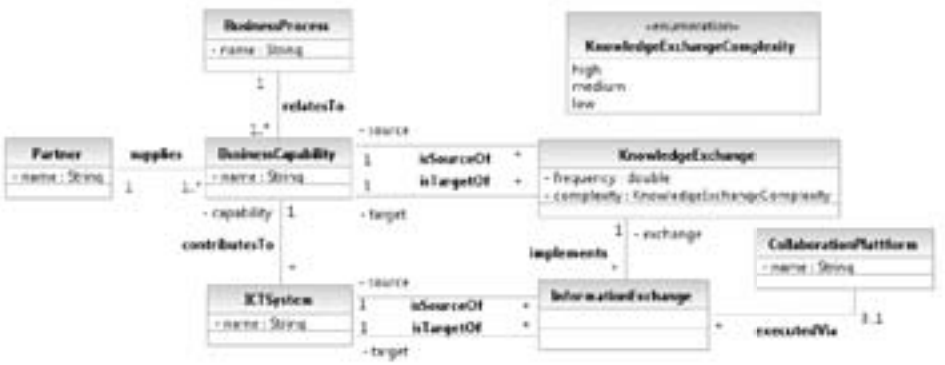

Figure 3: Information model fragment for Information Model Pattern ICT Network Support

This information model is complemented with two OCL constraints, used to ensure consistency between the descriptions of the knowledge network and the ICT network:

```
context InformationExchange
inv:  source.capability == exchange.source
inv:  target.capability == exchange.target
```

4.5 Known Uses

At the DITF-MR, similar information models have been created and are used as basis for the Smart Network modelling method.

4.6 Consequences

Gathering the information as demanded in this Information Model Pattern is a crucial task in this context. This is especially true, as information on the used ICT systems has to be collected from the different partners of the Smart Network. This might be not without problems due to two reasons. On the one hand, the partners are perhaps not willing to share information on their used ICT systems, especially with other partners providing a business capability supporting the same process. On the other hand, cross-organizational information collection is likely to be impeded by the absence of a central governing structure or organization. The second issue nevertheless can be resolved, if a mediating partner is liable for information collection.

A benefit of this Information Model Pattern might be the support for the evolution of the Smart Network, e.g. concerning the introduction of a new partner into the network. Using the information stored according to the Information Model Pattern makes it much easier for late entrants to understand the knowledge and ICT network level currently operated.

4.7 See Also

Information stored according to this Information Model Pattern can be presented in a view according to Viewpoint Pattern *ICT Network Map*, shown in Section 3.

5 Acknowledgement and Outlook

The creation of patterns for an EA management topic is no one-time task nor has it been the work of the authors only. Thus, we would like to thank all the people, who helped to improve this article by their feedback and remarks. Concluding, we give a short outlook on next steps, which could be taken to evolve the patterns presented here and extend them towards other application areas.

5.1 Acknowledgements

We want to thank all participants of the *Patterns in Enterprise Architecture Management (PEAM)* workshop at the *Software Engineering 2009* conference. Especially, we want to express our gratitude to Prof. Peter Sommerlad, the shepherd of this article, for the time spent on reading, commenting, and discussing the article. The work presented in this paper was carried out partially in the context of the AVALON project co-funded by the European Commission under the 6th Framework Program. The authors acknowledge the comments and contributions of the project partners.

5.2 Outlook

The Methodology Pattern, Viewpoint Pattern, and Information Model Pattern presented in this article are an initial attempt to apply the EA management pattern approach in the

context of Smart Network management. Thus, the field of ICT networking was exemplarily taken, omitting the organizationally more complex problem of initialization and set up of a Smart Network on the organizational and knowledge network level. Nevertheless, while yet no methodology, i.e. no Methodology Pattern(s) for these tasks have been presented, especially Viewpoint Pattern *ICT Network Map* and the respective Information Model Pattern *ICT Network Support* may prove useful tools in this context.

Planning the ICT network supporting knowledge exchange, which is supported by the patterns presented in this article, is a first step towards an ICT supported Smart Network, which is followed by a couple of also important steps. These steps, including *implementation* and *maintenance* of the ICT network, also demand for appropriate management and could thus be supported by EA management patterns. Therefore, further patterns should be created in order to provide seamless management support for the entire lifecycle of a collaborative ICT network. These patterns could use the ones presented in this article as a starting point, but would have to take additional aspects, e. g. the dismissal of a partner, into consideration. In this context also time–related aspects, as discussed in [BEMS08], should be taken into account.

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