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Günter Schicker
University of Erlangen-Nuremberg

Jörg Purucker
University of Erlangen-Nuremberg

Freimut Bodendorf
University of Erlangen-Nuremberg, bodendorf@wiso.uni-erlangen.de

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Günter Schicker, Jörg Purucker, Freimut Bodendorf

Department of Information Systems
University of Erlangen-Nuremberg
Lange Gasse 20
90403 Nuremberg, Germany
bodendorf@wiso.uni-erlangen.de

Abstract

Coordination and controlling in healthcare networks becomes increasingly important to enable integrated care scenarios, to enhance patient satisfaction and to reduce costs of the treatment processes. Based on the balanced scorecard a process-oriented approach for performance measurement in healthcare networks is introduced. The underlying systems architecture is presented. Integrating data from different sources and providers enables the calculation and visualization of key performance indicators in a network performance cockpit. Compliance scorecards are used to implement the network strategy and to ensure the achievement of goals. Real-time process data is obtained from a component that controls the flow of interorganizational treatment processes by web service technology. This component also supports treatment processes by process oriented e-services.

1 Introduction

The healthcare industry is one of the most important economic sectors in Germany causing annual expenses of about 230 billion euros (over 10 percent of the gross domestic product of Germany) and employing more than 4.2 million people. The German healthcare system is facing massive challenges due to the demographic and economic development as well as the increasing costs for medical innovation. Furthermore the quality is judged to be not better than mediocre [Ramm04, 147]. To improve patient satisfaction and to reduce costs of treatment processes by enhancing the cooperation between the healthcare providers a lot of different healthcare networks have been founded. In Germany the law "GKV-Modernisierungsgesetz" enacted in 2003 improved the possibilities to realize integrated care mechanisms especially establishing cross-sectoral healthcare networks. An empirical study reveals that 81 percent of the respondents expect that networking in the healthcare industry will increase in the next three to five years [ScKB06, 17]. Moreover 88 percent of the survey participants agree that the demand for coordination and IT-support in healthcare networks is going to rise in the future. The study initiated at the Department of Information Systems II at the University Erlangen-Nuremberg addressed german and suisse ambulant healthcare networks (healthcare network managers as well as physicians). The survey investigated the maturity of healthcare network organizations regarding strategy, processes, and information technology. Only five of 90 networks show good results in overall maturity. Especially in regard of network controlling there are still a lot of challenges to cope with. Whereas three of four participants of the above mentioned survey agree that goals for the network are clearly defined only 17 % have a structured controlling system in place. Moreover just a small minority measures key data of the network to realize performance gaps. To evaluate the achievement of objectives and to improve performance more transparency by introducing an IT-supported controlling system is needed. Otherwise the advantages of healthcare networks regarding quality, efficiency and patient sovereignty can not be proved and as a result the existence of network organizations cannot be assured.

2 Research Project

The research project focuses on the IT-driven management of healthcare networks. Whereas many research projects deal with the integration of health data (e.g., electronic health records [ScKB06, 45]) this project focuses on coordination and control of interorganizational processes. Goal of the project is to support coordination and control of healthcare network processes by providing healthcare suppliers and network managers with a customized set of electronic services. Based on a balanced scorecard approach a healthcare performance cockpit delivers information for healthcare network managers and service providers. Process portals enable the interaction between users (e.g., patients, physicians) and the use of e-services provided by the system [for details see ScBo05, 7]. A process integration platform is realized enabling the design and runtime execution of a process-based e-service logistics. To analyze the requirements of network controlling the research team cooperates with the healthcare network

"Qualitäts- und Effizienzgemeinschaft Nürnberg-Nord (QuE)" which is organized as a gatekeeper system [WaLF05, 13]. The integrated care contract spans ambulant, clinical and home care service providers and is financed by a full capitation model.

3 Process-based E-Service Logistics

The concept of process-based e-service logistics is based on the interdisciplinary coordination theory. „Coordination is managing dependencies between activities performed to achieve a goal" [MaCr90, 361]. Whereas this definition is widely accepted coordination theory deals with many different means of coordination (e.g., based on forms, conversation structure or information sharing). This project argues for a process-oriented approach of coordination supported by process models as a special kind of plan in terms of coordination theory. To transfer the general tasks and principles of coordination to the healthcare domain it has to be analyzed who is cooperating and which processes and coordination tasks exist within healthcare networks.

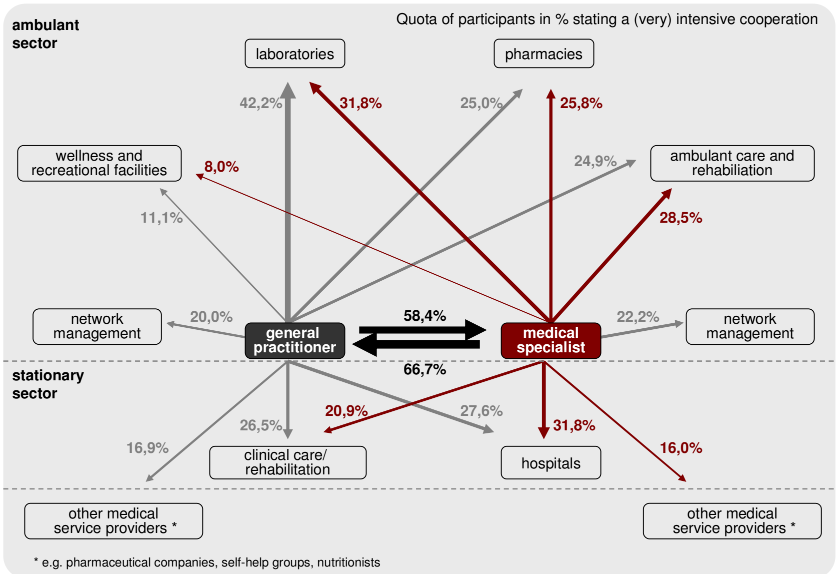


Figure 1: Intensity of cooperation

Figure 1 shows actors within integrated healthcare networks and the intensity of cooperation [ScKB06, 21]. The results show that intensive cooperation is taking place across sectoral borders resulting in numerous coordination tasks along interorganizational treatment processes. Table 1 shows some examples of processes, tasks and supporting e-services.

The research project focuses on the treatment process from a cooperative view regarding the patient's way throughout the whole healthcare network. The individual characteristics of each patient, the high degree of volatility of each process and its complexity have to be considered when supporting the execution of individual processes by information technology (e.g., individualization, adaptability, flexibility) [ScBo06].

healthcare network processes	coordination tasks	e-services
management processes: needed to control the healthcare network	goal adjustment, network monitoring and reporting, planning, guideline implementation	healthcare performance cockpit (balanced scorecard, stakeholder-specific reports)
medical treatment processes[1]: adding value to patients and resulting in revenue for healthcare providers	controlling health status of patients, exchange and adjustment of medical reports, discharge letters or prescriptions	patient monitoring service (e.g. bluetooth scale), electronic prescriptions, electronic discharge notes
support processes: enabling processes laying the foundation to run the business	absorption of costs, accounting, billing and payment, master data management	web service orchestrated workflows for cost absorption, e-billing, patient master index

Table 1: Processes, tasks, e-services

The concept of process-based e-service logistics aims to support the coordination of healthcare network processes by providing patients and healthcare suppliers with a customized set of electronic services. Electronic services are software components which encapsulate functions (e.g., logic or data centric services) in a coarse-grained manner, e.g. using web services as technical representation [KrBS04, 70ff]. The e-service requirements regarding information and coordination in healthcare networks are derived from customized process models. They result in a process-based e-service logistics model executed by a process management platform (Individual Value Web System IVWS) supporting the coordination of individual treatment processes by providing network participants with e-services. At the level of individual patient instances treatment processes and the flow of activities throughout the network are coordinated by a gatekeeper model. The gatekeeper system aims to improve the quality of care and to realize synergies during the treatment process e.g. by avoiding unnecessary medical examinations. One member of the healthcare network is the contact person (gatekeeper) collecting all information about the patient and coordinating his treatment. The system architecture has to support this gatekeeper concept which defines the business architecture within the healthcare network [AiDo05, 614]. Hence, the central execution of web service-based workflows [BGHS03, 61] is the basic technical principle ensuring a high degree of structural analogy of business and systems architecture. To achieve this, the research project uses web service technology and the concept of service oriented architecture as technical basis. The process and e-service scheme instantiated at the first stop of the patient in the healthcare network is executed by the IVWS (for details see [ScBo06]). Figure 2 shows the architecture of the IVWS. The Meta-

[1] In literature several terms are used for medical treatment processes (e.g. guidelines, clinical/ critical pathways, interdisciplinary care paths) pointing out different origins, goals and perspectives [GlSS04, 19; GrMW03, 22ff; John02, 13].

Orchestration-Server (MOS) enables the execution of individual processes and e-services that can be customized at run time.

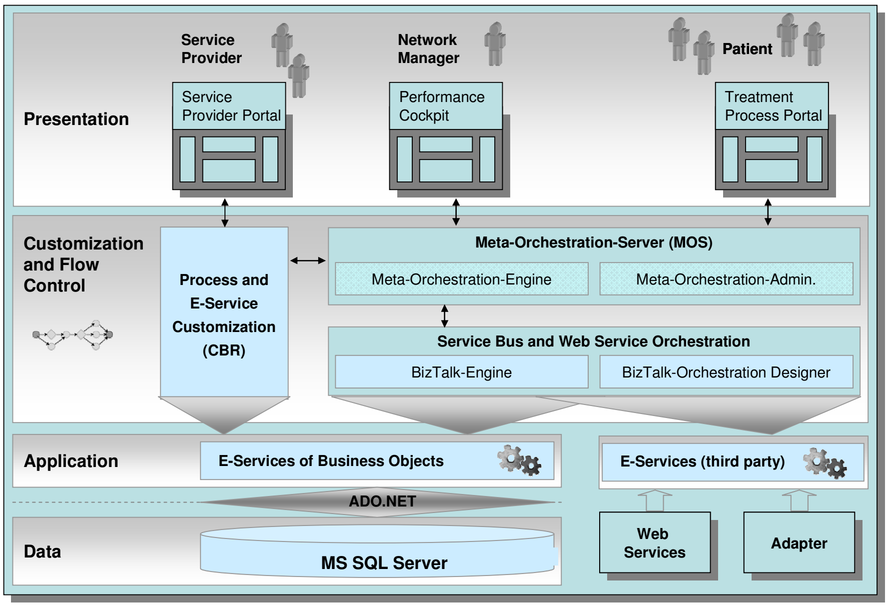


Figure 2: Architecture – Individual Value Web System (IVWS)

The system distributes e-services to roles across the network and informs the gatekeeper about the patient status. Thus the gatekeeper gets transparency concerning the treatment process giving him the possibility to intervene if necessary. The research work is based on the concept of a process-enabled service-oriented architecture (SOA). It enables "lightweight" application frontends which are only responsible for interacting with system users (dialog control). Moreover the concept argues for the encapsulation of processes within process centric (web) services. The complexity of backend systems is encapsulated within intermediary services. As a result the separation of process logic (within a process layer) and business logic (within a basic services layer) is assured [KrBS04, 79].

4 Performance Measurement in Healthcare Networks

Performance measurement is a controlling approach that focuses on the assessment of effectiveness and efficiency in companies by especially considering strategic relevant aspects including non-monetary measures [Glei02, 447]. The process-based approach for performance measurement which is described in this section relies on process data. Therefore the central process management platform that was described in section 3 is one important source of data.

4.1 Requirements

Table 2 shows crucial requirements for performance measurement systems in healthcare networks. Domain neutral requirements are relevant for network performance measurement systems not regarding the specific domain, whereas domain specific requirements are aligned to healthcare networks. Because of the given autonomy of actors within a network the network strategy must be developed and operationalized in a cooperative manner [Cors00, 24]. A big challenge for performance measurement is the extraction and integration of data from heterogeneous network actors by taking care of data privacy [LiSS04, 108; Wenn03, 62; PaBr01, 167]. Another challenging task is the definition of measures that reflect the network compliance of healthcare suppliers and that can be compared across the network and to external suppliers [Wenn03, 57ff]. Measures that reflect the network compliance must be influenceable by the suppliers in question. Process related measures can be retrieved by process data but decrease the freedom to act and therefore might badly influence the motivation. On the other hand outcome related measures are hard to calculate and mostly depend on factors that can hardly be influenced by healthcare suppliers (e. g., existence of multiple diseases, occurring of complications, patient and supplier cooperation) [PiRW03, 538ff; AQUA02, 6].

Domain neutral	Domain specific
• alignment to network goals • cooperative development and operationalization of network strategy • integration of heterogeneous IC-Systems • taking care of acceptance • prompt success control • operationality • comparability of results between different actors in different periods of time • alignment of incentives to network goals and network compliance	• considering goals and needs of stakeholders in healthcare networks • controlling of medical treatment processes • planning and monitoring of performance on network and supplier level • comparability to other healthcare networks and suppliers • considering policy holder structure • identification of potentials to develop supplier structure • considering relationships to external healthcare suppliers • taking care of data privacy • avoiding additional effort for documentation • balance of process and outcome related measures

Table 2: Requirements for performance measurement systems in healthcare networks [ScKB06; Wenn03; Toph03]

4.2 Concept

The concept introduced in this section is based on the balanced scorecard which not only because of its flexibility is said to be the most promising approach in performance measurement [Glei01, 88f]. The balanced scorecard approach is particularly appropriate for controlling in networked organizations. It explicitly addresses the implementation of a strategy throughout an organization by developing and integrating several dependent scorecards [PiRW03, 573ff]. Figure 3 shows the performance measurement process as a basis for the concept to be introduced in this chapter.

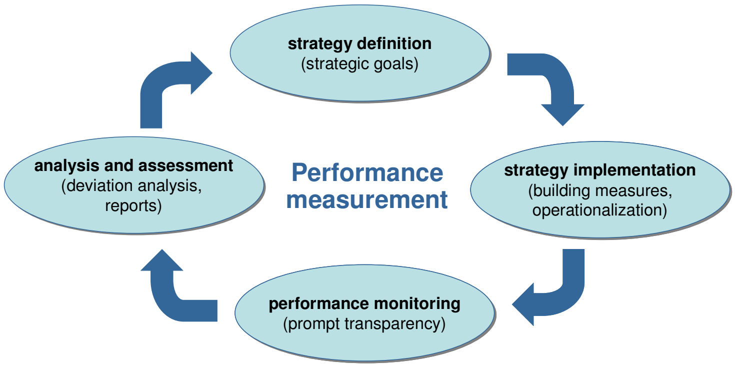


Figure 3: Performance Measurement Process

4.2.1 Strategy definition

Defining a network strategy is the first task in the performance measurement process. For this purpose the network strategy needs to be coordinated between the network management, the internal suppliers and the external partners (e. g. insurance company, association of CHI physicians). Strategy maps can be used as communication instrument [Horv04]. Figure 4 shows an exemplary strategy map for a healthcare network. Unlike in pure social organizations the mission in healthcare networks is related to economic and social aspects. Whereas in pure social organizations the financial perspective of the balanced scorecard can be placed below the process perspective to express that finance is the base for the work in the organization and for achieving the customer related goals, in healthcare networks financial goals play a more important role. Because of the causal relationship between financial and customer related goals, it is suggested to keep the financial perspective above the customer perspective. The importance of social issues can be expressed by connecting goals that are relevant for social aspects to the strategic imperatives that should be placed above the balanced scorecard perspectives [KaNo01, 120f].

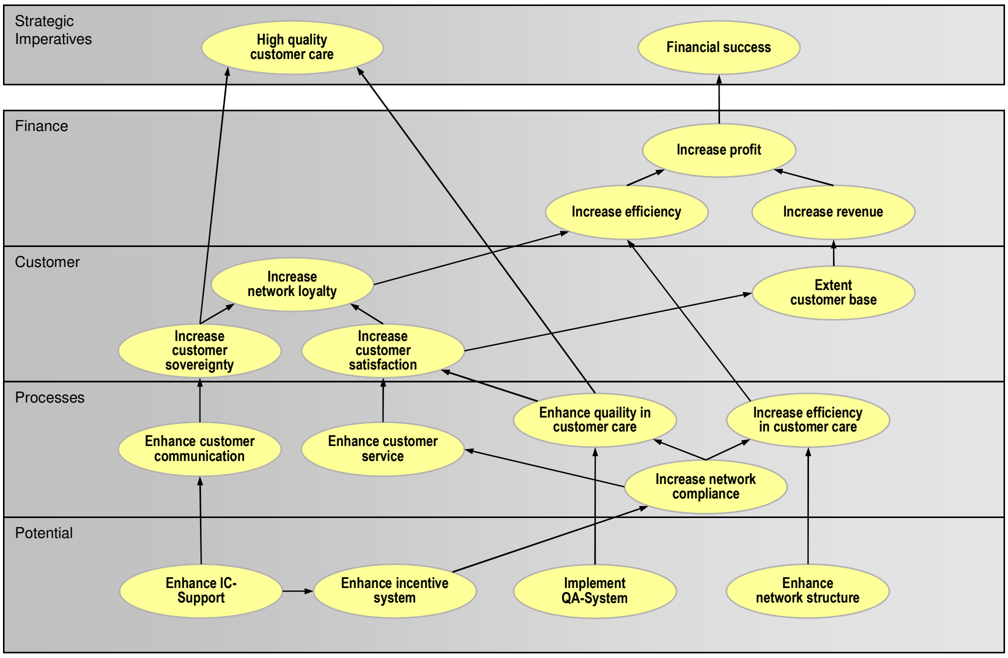


Figure 4: Strategy map for a healthcare network

4.2.2 Strategy implementation

Implementing the network strategy includes defining measures and targets, operationalizing the strategy and aligning incentives to the strategy. These tasks need to be fulfilled in coordination between the network management, the internal suppliers and the external partners. Measures need to indicate the degree of goal achievement. They must be clearly interpretable and influenceable by the actors. Collecting data should not cause too much effort [Horv04, 224]. As part of the research project for each measure in the scorecard of the healthcare network “QuE” potential data sources are retrieved. The measures were arranged in the dimensions relevance and ease of retrieving data to show which information demands can be fulfilled easily, what additional data is needed and what the retrieve costs are.

Operationalizing the strategy can be done by executing projects related to strategic goals. Another way of strategy operationalization is to create more detailed measures and scorecards across the network by building hierarchies. In Figure 5 the balanced scorecard for a healthcare network is translated to more detailed scorecards in order to specify the contribution of network actors to the network strategy. The scorecard for physicians is deduced from the network scorecard and further concretized in scorecards related to special types of physicians like gatekeepers. In this example the scorecard for gatekeepers has own measures and adopts all measures from the scorecard for network physicians. The targets can be specified.

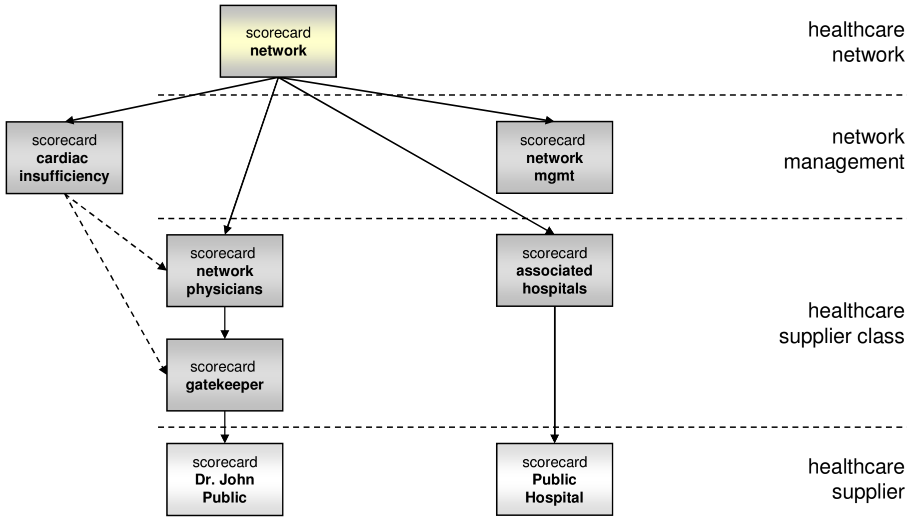
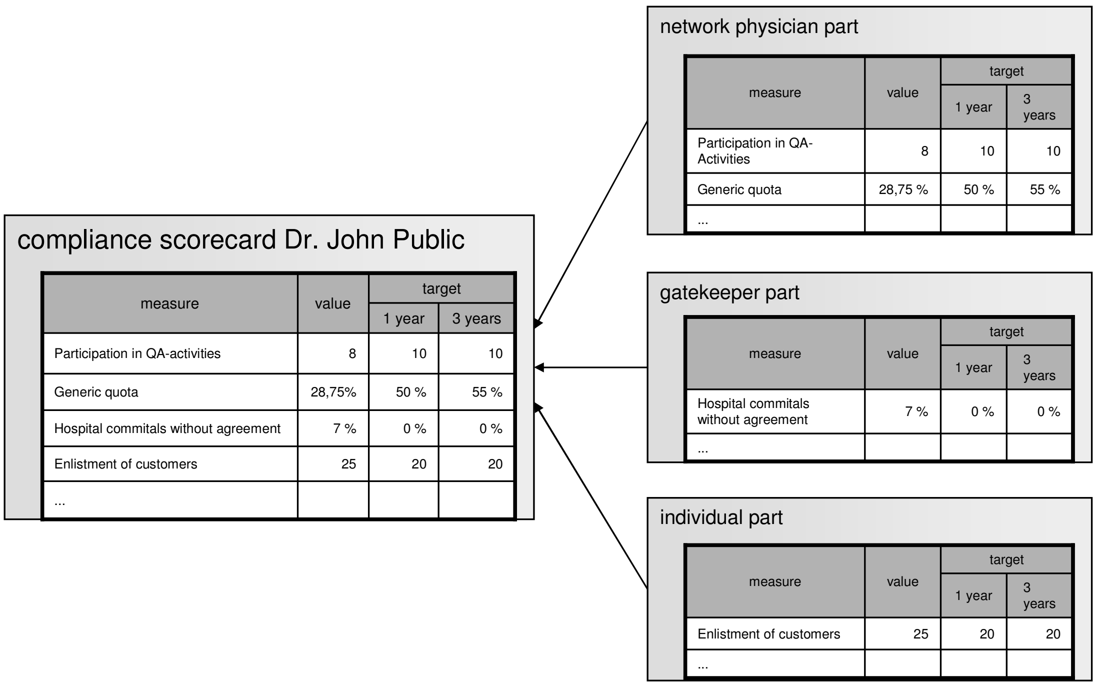


Figure 5: Building scorecard hierarchies

As suppliers in healthcare networks are organizationally independent the network management can not dictate scorecards to them. On the other hand there are directives substantiated in contracts that need to be controlled. For that reason compliance scorecards were implemented which do not necessarily reflect all goals of the suppliers but specify criteria for measuring the suppliers' network compliance. Figure 6 shows an example.



network physician part

measure	value	target	
		1 year	3 years
Participation in QA-Activities	8	10	10
Generic quota	28,75 %	50 %	55 %
...			

gatekeeper part

measure	value	target	
		1 year	3 years
Hospital commitals without agreement	7 %	0 %	0 %
...			

individual part

measure	value	target	
		1 year	3 years
Enlistment of customers	25	20	20
...			

compliance scorecard Dr. John Public

measure	value	target	
		1 year	3 years
Participation in QA-activities	8	10	10
Generic quota	28,75%	50 %	55 %
Hospital commitals without agreement	7 %	0 %	0 %
Enlistment of customers	25	20	20
...			

Figure 6: Exemplary compliance scorecard

In healthcare networks medical treatment processes and other network processes need to be considered when operationalizing the network scorecard. For that reason process related scorecards (e. g. for important indications like cardiac insufficiency or for medication) can be built in an appropriate network board. These process scorecards need to be translated to and coordinated with the scorecards that are related to the network actors. Figure 5 shows an example for building a process-based scorecard hierarchy.

In the traditional German healthcare system there is a permanent incentive for suppliers to enlarge their services and hence cause immense costs for the system (hamster wheel effect). In contrast, the behavior of the network supplier needs to be aligned to network goals in full capitation healthcare networks. This can be done by implementing an incentive system. The measures in the compliance scorecard could form the assessment base for this incentive system. If the network is financed by a full capitation model, the amount of money to be distributed can be determined by the incentive system. The more money the network physicians save (e. g. by avoiding not necessary examinations), the more money can be shared. One effect of an incentive system could be that network physicians are more aligned with the assessment base than with the network goals. To avoid an abuse of the incentive system common values and mutual trust are indispensable [PiRW03, 543].

4.2.3 Performance monitoring

In order to implement a performance measurement system relevant data needs to be retrieved from different data providers. Internal health suppliers provide data related to medical treatment processes. In a web-service-based approach as described in section 3 data from external suppliers is integrated as well. External partners provide additional data regarding enlisted patients and internal physicians beyond the network processes. Network management provides additional data that was produced inside the network (e.g. surveys regarding customer and member satisfaction) or obtained externally (e.g. medication data).

Collecting, processing, and using personal data is subject to sever conditions regarding data privacy. In healthcare networks these conditions refer to patients and physicians. Processing health-related data needs to be approved by patients or governed by law. Approvals by patients are tied to the medical treatment process and to one institution. Data that was de-personalized by using anonyms or pseudonyms can be used without any patient approval. In contrast to anonyms, pseudonyms can be used to integrate data from different data sources when the same de-personalization key is used. This key must be kept secret, because otherwise mapping tables can be built to gather personalized information [Dier02, 232ff]. Because of the unclear legal position and the high demands related to the collection and processing of personalized data in the research project de-personalized data is used only.

To migrate data from different data providers in a central data pool an ETL-Process (Extraction, Transformation, Load) needs to be implemented. As data providers use different keys for de-personalization data can not be migrated on the level of pseudonyms. Therefore in a first step data is migrated in provider specific data marts. Afterwards parts of the data marts are migrated to a central data warehouse. Regarding patients the migration must be performed on a higher level of aggregation. In a long-term view it needs be examined whether the single data providers could share the de-personalization key by using appropriate security mechanism.

As relational database systems are not an adequate solution for ad hoc analyses in vast databases, relational data can be converted to multidimensional data whenever necessary. The multidimensional data which is stored in an OLAP server can be used for many purposes as for calculating measures in scorecards and reports or performing ad hoc queries.

4.2.4 Analysis and assessment

Based on the retrieved data the network management creates reports related to the network processes and the network compliance. The healthcare suppliers can access reports automatically created regarding their individual network compliance. Figure 7 shows which features are implemented in the performance cockpit so far and what will be done in a stage of extension.

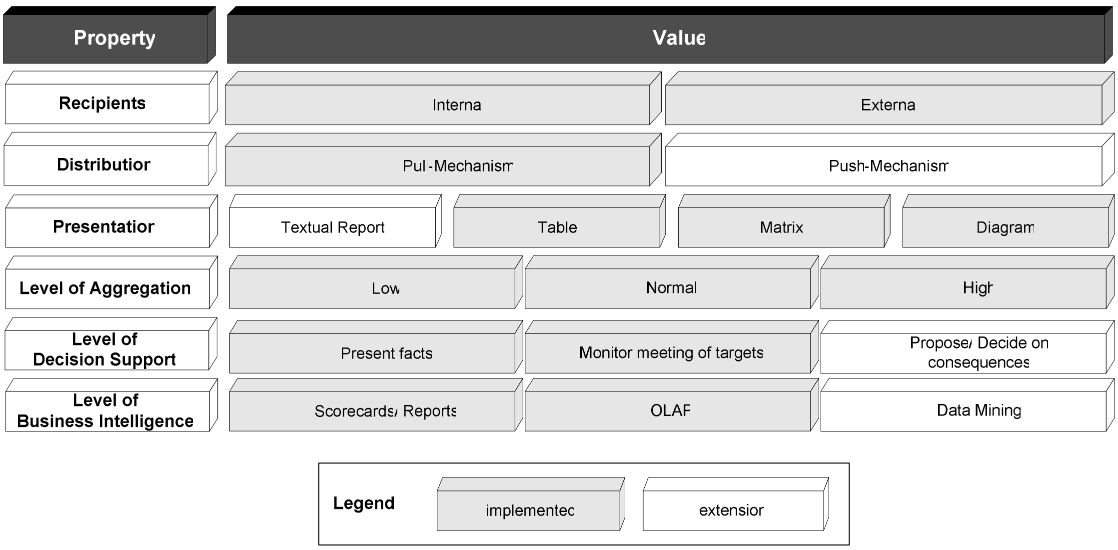


Figure 7: Analyses and report systems in healthcare networks

Reports are automatically created but can be reviewed and adjusted before being presented to external stakeholders. The reports are accessed on demand (pull-mechanism). In certain cases reports can also be automatically distributed depending on the situation and user needs (push-mechanism). Reports are presented as tables, matrices or diagrams. The performance cockpit presents facts and monitors the achievement of goals, but does not yet propose or decide on consequences. This will be the next step when implementing an incentive system.

4.3 Technical Implementation

Figure 8 shows the architecture of the network performance cockpit. It follows the principle of SOA. Application frontends control user interaction, whereas the functionality is realized by e-services with a web service interface [KrBS04, 55ff].

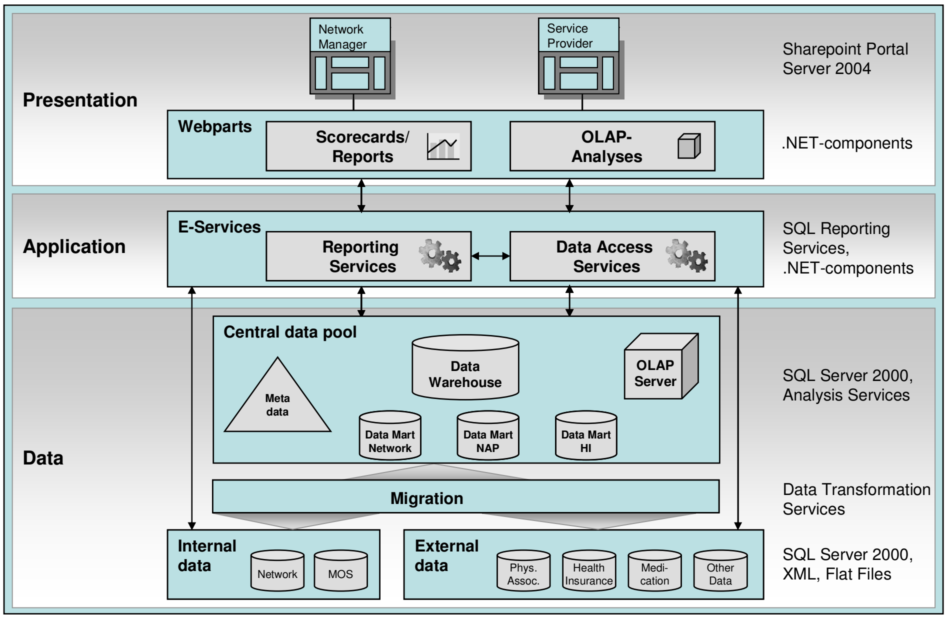


Figure 8: Performance Cockpit Architecture

4.3.1 Data Layer

Figure 9 represents important data sources for healthcare network controlling.

xDT: xDT is a collection of interfaces provided by the central institute for statutory medical care. The different xDT interfaces define a set of fields and a corresponding order. Today only ADT is a real standard as it is used for the exchange of billing data. This standard provides billing data and billing diagnoses but no medical data related to treatment processes (e. g. findings, therapies, medication). BDT includes treatment data, but most of it can not be interpreted because the contents of the corresponding fields are not well-defined [LiSe94]. However for many surgery information systems the medication data inside BDT can be interpreted. The STDT standard was implemented by two surgery information system providers only.

Figure 9: Data sources

MOS: The Meta-Orchestration-Server (MOS) is the central process management platform as described in section 3 which aims to support the coordination of healthcare processes. Therefore, the corresponding data scheme contains medical treatment processes, services, customer tasks, coordination tasks, e-services, and patient data. The treatment processes and corresponding elements are well-defined in a database scheme.

Network management: The network management provides data that is generated in the network, including physician master data, data regarding network activities, the status of quality management, strategic and operative planning data and data generated by customer and member surveys.

Health insurance: Insurance companies provide patient related data generated inside and beyond the network (e.g. treatment data from hospitals). This data is very important for the network management as in a full capitation model the network also has to pay for patient treatment beyond the network. The data is delivered after billing which causes a delay of about 9 months.

Association of CHI physicians: The association of CHI physicians provides data generated in the ambulant sector inside and beyond the network. The data is delivered after billing which causes a delay of about 9 months.

Other data: Depending on the need additional external data sources (e.g. medication catalog) can be integrated. In the future the telematics infrastructure especially the electronic patient record can become an important data source for patient and treatment data.

For controlling issues prompt transparency regarding the network performance is very important. As the data supply by external partners is carried out with a substantial delay, internal data needs to be retrieved. By use of the xDT interfaces data can be generated daily, but can only partly be interpreted. The implemented performance cockpit uses data generated by the MOS to show potentials related to controlling in healthcare networks. As the internal data is limited to treatment processes planned inside the network, external data supplied by health insurance companies and the association of CHI physicians needs to be integrated anyway.

4.3.2 Application Layer

Figure 10 shows the applied e-services grouped in two e-service modules. The SQL Reporting Services from Microsoft provide a web service interface to create and adjust reports. The Microsoft Analysis Services provide access to multidimensional infocubes by MDX (Multi-dimensional Expressions) a language with a syntax similar to SQL. All other e-services were developed within the research project.

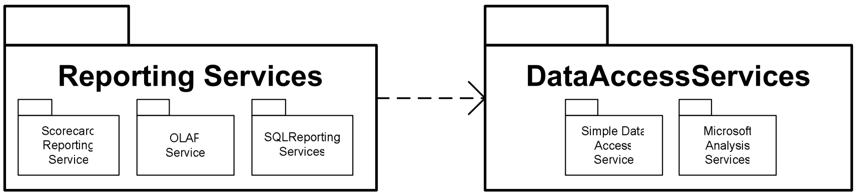


Figure 10: e-service modules

4.3.3 Presentation Layer

Figure 11 shows a management dashboard that visualizes the current network performance on a high aggregation level. For more details users can drill down to the process perspective with its goals and related measures (see Figure 12).

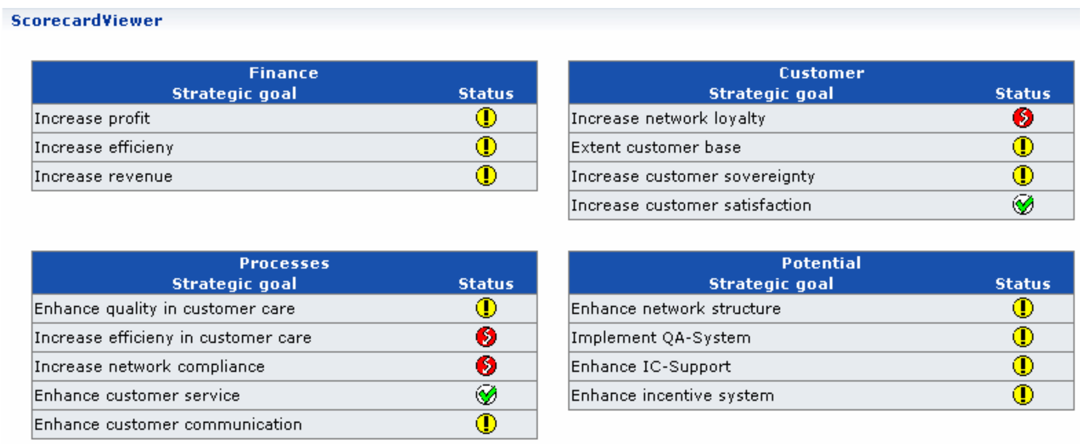


Figure 11: Dashboard for an exemplary balanced scorecard

ScorecardPerspectiveViewer

Processes					
Strategic goal / Measure	Status	Value	Trend	Target 06	Target 07
⊞ Enhance quality in customer care					
⊞ Increase efficieny in customer care					
⊟ Increase network compliance					
compliance to directives related to medical services		36 %		80 %	90 %
compliance to directives not related to medical services		65 %		80 %	90 %
⊞ Enhance customer service					
⊞ Enhance customer communication					

Figure 12: Process perspective of an exemplary balanced scorecard for healthcare networks

The status symbols are calculated by comparing the current value to the target value taking account of the target type (max, min, point). The compliance scorecard viewer webpart assesses the healthcare suppliers' network compliance. In Figure 13 the compliance scorecard consists of three parts. The first part applies to all network physicians, the second to all gatekeepers and the last one just to Dr. Public containing an individually negotiated target value for customer enlistment.

ComplianceScorecardViewer

Dr. John Public					
Report part / Measure	Status	Value	Trend	Target 06	Target 07
⊟ Network Physician					
Participation in quality activities		8		10	20
Generic quota		28,75 %		50 %	55 %
⊟ Gatekeeper					
Hospital commitals without agreement		7 %		0 %	0 %
⊟ Dr. John Public					
Enlistment of customers		25		20	30

Figure 13: Exemplary compliance scorecard related to a gatekeeper

In addition to that an OLAP Viewer enables users to navigate in multidimensional infocubes to process ad-hoc-queries.

5 Conclusion

A strategy-oriented concept for process-based performance measurement in healthcare networks was designed and prototypically implemented. The solution was developed in cooperation with an innovative healthcare network which is organized as a gatekeeper system with a full-capitation model. By monitoring medical treatment processes prompt transparency regarding network performance is reached. One important challenge for the future of performance measurement in healthcare networks is the extraction and integration of heterogeneous data by guaranteeing data privacy. Therefore standards regarding data interfaces need to be defined. In a full-capitation model treatment processes must also be monitored beyond the borders of healthcare networks and sectors. To ease comparisons between healthcare suppliers and between healthcare networks standard measures need to be developed and implemented. Next steps will be the integration of incentive systems ("pay for performance") and the use of more sophisticated methods for analyzing performance data like data mining and simulation.

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