An analysis of contractual and transactional aspects of a cardiothoracic surgery process

Technische Universiteit Eindhoven, department of Technology Management, Information Systems group:
ir. Jochem Vonk,
M.Sc Ting Wang,
Prof. Dr. ir. Paul Grefen

Catharina Ziekenhuis Eindhoven, behandelecentrum:
Dr. Floor Haak – van der Lely
Jan van Aarle
Thoraxcentrum:
Suzan Brugmans
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>5</td>
</tr>
<tr>
<td>1.1 The Healthcare Domain</td>
<td>5</td>
</tr>
<tr>
<td>1.2 The XTC Project</td>
<td>5</td>
</tr>
<tr>
<td>1.3 Case Study: XTC in the Cardiothoracic Surgery Process</td>
<td>7</td>
</tr>
<tr>
<td>2 The CTS Process</td>
<td>8</td>
</tr>
<tr>
<td>2.1 Main CTS Process</td>
<td>8</td>
</tr>
<tr>
<td>2.2 CTS subprocesses</td>
<td>11</td>
</tr>
<tr>
<td>2.2.1 Policlinic Pre-Operative Screening (PPOS)</td>
<td>11</td>
</tr>
<tr>
<td>2.2.2 Admission Process</td>
<td>12</td>
</tr>
<tr>
<td>2.2.3 Daily Pre-Op Routine at Afdeling 6-West</td>
<td>13</td>
</tr>
<tr>
<td>2.2.4 Operation</td>
<td>13</td>
</tr>
<tr>
<td>2.2.4.1 Prepare patient for Surgery</td>
<td>14</td>
</tr>
<tr>
<td>2.2.4.2 Surgery</td>
<td>15</td>
</tr>
<tr>
<td>2.2.5 Intensive Care</td>
<td>15</td>
</tr>
<tr>
<td>2.2.6 PostPACU</td>
<td>16</td>
</tr>
<tr>
<td>2.2.7 Daily Post-Op Routine at Afdeling 6-West</td>
<td>18</td>
</tr>
<tr>
<td>2.2.8 Discharge</td>
<td>20</td>
</tr>
<tr>
<td>3 Agreements</td>
<td>21</td>
</tr>
<tr>
<td>3.1 Intra-Organizational</td>
<td>21</td>
</tr>
<tr>
<td>3.2 Inter-Organizational</td>
<td>22</td>
</tr>
<tr>
<td>4 Service Oriented View</td>
<td>23</td>
</tr>
<tr>
<td>5 Introducing the XTC concepts in the CTS process</td>
<td>25</td>
</tr>
<tr>
<td>5.1 The FIAT attributes</td>
<td>25</td>
</tr>
<tr>
<td>5.2 Abstract Transactional Constructs</td>
<td>27</td>
</tr>
<tr>
<td>6 Advanced opportunities using XTC in CTS</td>
<td>29</td>
</tr>
<tr>
<td>7 References</td>
<td>30</td>
</tr>
<tr>
<td>8 Appendix</td>
<td>31</td>
</tr>
<tr>
<td>8.1 Service Level Agreements – CTS / OR / ICU</td>
<td>31</td>
</tr>
<tr>
<td>8.2 Service Level Agreements – CZE / Other hospitals</td>
<td>33</td>
</tr>
</tbody>
</table>
1 Introduction

1.1 The Healthcare Domain

Processes in the healthcare domain are mostly very complex. They contain numerous subprocesses and activities covering multiple departments and/or organizations. Included subprocesses range from relatively simple daily routine tasks to complex medical procedures. As healthcare processes deal with patients, reliability of such processes is even more important than it is in many other complex business processes.

Recent years show a trend in increasing numbers of collaborations between organizations, ranging from simple outsourcing of subprocesses to complex business network processes [GMK07]. With the developments in information technology, the same trend is starting to appear in the healthcare domain as well. Already existing examples are TeleRadiology [Sch06] (the acquisition and/or interpretation of medical scans is outsourced to specialized organizations) and telemedicine (the modern version of 'in absentia healthcare'). Through this trend, the main focus will shift from the departmental functional view (as it is now) towards a cooperation view involving healthcare providers from different medical disciplines and organizations (as it can be in the future).

From a patient viewpoint, the healthcare processes should be transparent (up to a certain level) and the quality of the process should be known (and measurable). More and more patients want to be able to choose their healthcare provider themselves, basing their choice on the quality of the healthcare process they will get involved in. This means that healthcare providers will start to focus more on improving the quality attributes (or 'prestatie-indicatoren' [PIZ08]) of their healthcare processes, so that they are able to distinguish themselves from other healthcare providers. A base-set of quality attributes (quality indicators) is given in [PIZ08]. An example of a more advanced quality attribute for a healthcare process can be the reliability of such a process, e.g., what is the chance a surgery will be canceled or postponed.

1.2 The XTC Project

Increasing process execution reliability is the focus of the XTC project, carried out at Eindhoven University of Technology and Tilburg University. XTC is an acronym for eXecution of Transactional Contracted electronic services. To facilitate process execution reliability the business transaction framework (BTF) has been developed. The BTF consists of
concepts, techniques, and methods that, when applied to a business process, increases its execution reliability.

Two key elements of the BTF are abstract transactional constructs (ATC) and transactional quality of service (TxQoS). ATCs provide flexible reliability in the execution of processes, by applying transaction management techniques [WGV06]. Cooperation between organizations usually takes place using services. A Service is a business function (implemented and/or supported by a business process) that is offered by an organization to other organizations. The agreements related to a cooperation are stated in an electronic contract. Agreements specifically related to services are contained in a service level agreement (SLA), which is part of the contract. The SLA in turn can contain a specific section handling transactional issues related to the service, called the transactional service level agreement (TxSLA). The TxSLA contains transactional quality of service specifications that together determine the reliability agreements (concerning that service) between the involved organizations.

Figure 1 shows the relation between the different concepts. Processes are supported by ATCs. TxQoS is specified for Services and contained in a TxSLA. Services contain processes (while process can contain or make use of services as well). As the actual execution of a service is done through the process it contains, the TxQoS of the service is guaranteed by the ATCs corresponding to the process. Services are governed by a SLA, which is included in the contract. The SLA itself contains the TxSLA.

Figure 1: ATC and TxQoS context
1.3 Case Study: XTC in the Cardiothoracic Surgery Process

To validate the business transaction framework, an extensive case study at the Catharina Hospital in Eindhoven (CZE), the Netherlands, is being conducted. Numerous highly complex processes are executing concurrently in such a hospital environment. Most of these processes involve more than one (more or less autonomous) hospital units between which a number of agreements exist. Also, as most processes involve patients, reliability in process execution is of vital importance.

The process considered in the case study is the Cardiothoracic Surgery (CTS) process. The CTS process involves patients that have to undergo heart surgery (e.g., a bypass, or a heart valve replacement). The CTS process includes the pre-operative screening, admittance to the hospital, stay at the CTS unit, the surgery, the stay at the intensive care unit, and the discharge of the patient from the hospital. To model this process, we have extracted the relevant information from the available documentation (flow charts, a patient-leaflet "Een hartoperatie", etc. [CZE08, Hut08, Bru04]) and from numerous discussions and interviews with the hospital staff involved in the CTS process. The process models are presented in Section 2. By taking a service-oriented view on the process, it is possible to explicitly identify the services involved in the process. By identifying services, it becomes possible to analyze and reason over the qualitative characteristics (or non-functional characteristics) of these services. Understanding the qualitative service characteristics makes it possible to improve them, which can in turn provide a competitive advantage (to CZE in this case) compared to similar services offered by other health care providers.

The scope of the XTraConServe project (and therefore this report) is restricted to the aspect of process reliability. Through the application of the developed business transaction framework the CTS process is complemented with structured exception handling, so that the overall quality and reliability of the CTS process is increased in the presence of occurring exceptions, which are unavoidable in a dynamic and unpredictable domain as health care.
2 The CTS Process

Patients who are diagnosed with a heart problem and need to undergo heart surgery are the 'subject' of the CTS process. Several types of surgery exist, e.g. bypass operation or replacement of a heart-valve. This section describes the CTS process using a number of process models, starting from a high-level view of the entire process and detailing the subprocesses thereof in subsequent subsections. The modeling notation used is that of electronic process chains (EPC), the legend of which is shown in Table 1 below.

Table 1: Legend for EPC diagrams

<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Event" /></td>
<td>Event: a status change. Can be caused by performing a function, but can also be caused by an external factor (e.g., time).</td>
</tr>
<tr>
<td><img src="image" alt="Function" /></td>
<td>Function: c.f. process activity or task</td>
</tr>
<tr>
<td><img src="image" alt="Organizational Unit" /></td>
<td>Organizational Unit: which organizational unit or role performs the associated function.</td>
</tr>
<tr>
<td><img src="image" alt="Exclusive Or-Split or Exclusive Or-Join" /></td>
<td>eXclusive Or-Split or eXclusive Or-Join. In case of a split: when the incoming arrow becomes 'true' (the previous event happened or the previous function was performed), only one of the outgoing arrows is 'followed'. In case of a join: when one of the incoming arrows becomes 'true', the outgoing arrow is 'followed'.</td>
</tr>
<tr>
<td><img src="image" alt="Or-Split or Or-Join" /></td>
<td>Or-Split or Or-Join. Similar to the exclusive or, except that more than one outgoing arrows (split) can be followed, or more than one of the incoming arrows (join) can be 'true'.</td>
</tr>
<tr>
<td><img src="image" alt="And-Split or And-Join" /></td>
<td>And-Split or And-Join. In case of a split, all outgoing arrows are followed incase the incoming arrow becomes 'true'. In case of a join: all incoming arrows must be 'true' before the outgoing arrow is followed.</td>
</tr>
</tbody>
</table>

2.1 Main CTS Process

A high level view of the main CTS process is shown in Figure 2. When a patient is diagnosed and it has been determined that he needs to undergo cardiothoracic surgery, this is scheduled and the dates on which the patient has to visit the hospital are determined. After scheduling, the patient has to wait (at home) until he is scheduled to take a pre-operative screening at the policlinic (PPOS). A number of days before the patient needs to visit the PPOS, a visit request
is send to the patient, together with some forms that need to be filled by the patient. The patient needs to take these forms with him when visiting the hospital to undergo the PPOS. After the PPOS, the patient has to wait (at home) until he is scheduled to be admitted in the hospital. On the admission day, the patient visits the hospital and is admitted to the ward (called 'Afd6-West'). The day(s) before the patient can undergo the surgery, the daily routine at the ward is performed. At the scheduled operation date, the patient is moved to the operation room in which the surgery takes place. After the surgery, the patient is moved to intensive care. The intensive care is divided into four levels of care: high care, post anesthesia care (PACU), intensive care, and medium care. Before the operation, the patient situation is evaluated and decided whether the patient has to receive high care or PACU (limited stay of 12 hours max.). When the patient recovered well enough during PACU care, he is moved back to Afd6-West and receives postpacu care. In the exceptional situation, in which the maximum time to stay at PACU has expired and the patient has not recovered well enough, the patient is moved to High Care. The patient can stay in high care, intensive care, or medium care for an undetermined amount of time. Each day (at around eight o'clock in the morning) it is decided whether a patient is moved from one level of care to another level of care, or moved back to Afd6-West. When the patient is back from surgery at Afd6-West or when he has recovered from postpacu, the daily routine is performed until the patient has recovered well enough to be discharged from the hospital, after which the CTS process ends.
Figure 2: Main CTS Process
Note: for the analysis of the process, it is not necessary that every function has an organizational unit specified that performs the function. In case the organizational unit is omitted, it is either trivially determined or not relevant for the analysis. This also holds for the subprocess models presented in the remainder of this section.

### 2.2 CTS subprocesses

The main process as shown in Figure 2 contains a large number of subprocesses (all functions in the diagram). Except for the trivial subprocesses ('Schedule Patient', 'Wait', 'Send request to visit PPOS', and 'Move to Afd6-West'), these subprocesses are detailed in this subsection.

#### 2.2.1 Policlinic Pre-Operative Screening (PPOS)

Before the patient can be admitted to the hospital to undergo the planned heart surgery, first the status of the patient needs to be determined and information between the patient and the involved persons of the hospital needs to be exchanged. This is collectively done during the patients visit to the policlinic pre-operative screening (PPOS). The visit lasts approximately half a day and a number of activities (screenings) will take place, the order of which is not important. The PPOS process is shown in Figure 3.
As can be seen in the figure, all activities (except 'take additional examinations') can be performed in parallel. Also, the activity 'take heart-lung photo' is optional.

2.2.2 Admission Process

After the patient visited the PPOS and all required information is gathered, the patient can be admitted to Afdeling 6-West in the Hospital (at the scheduled date). The process model of the admission subprocess is shown in Figure 4. When the patient arrives at the hospital, his status is compared to the status acquired during the PPOS visit. If the status has changed, appropriate action is taken by the nurse practitioner (NP) or 'Arts-Assistent' (AA). Note that this is again a subprocess, which is not further detailed here. After the status check (and possible additional actions) a bed is determined for the patient and the patient is admitted to this bed on Afdeling 6-West. However, the exceptional situation can occur that no bed is available on Afdeling 6-West. In this case the patient is moved (and admitted) to another department. On the first day of the hospital stay, the verpleegkundige (VK) enters the determined medication for the patient in the hospital information system (HIS) and the arts-assistent performs a check on the entered medication. What medication a patient requires has already been determined during the PPOS visit.
2.2.3 Daily Pre-Op Routine at Afdeling 6-West

This subprocess is not detailed any further in this report. This subprocess is rather similar to the daily post-op routine, of which a detailed decomposition can be found in Section 2.2.7. The daily pre-op routine contains activities like washing, eating, drinking, taking medication, etc.

2.2.4 Operation

The operation subprocess can be further divided into subprocesses: a preparation subprocess to prepare the patient for the actual surgery, a subprocess in which the operation room (OR) is prepared, and a process that describes the surgery process itself. The order in which these subprocesses have to take place is shown in Figure 5. First the patient and the operation room
need to be prepared (which can be done in parallel), after which the actual surgery can take place. In the next two subsections, the 'prepare patient for surgery' subprocess and the 'operation/surgery' subprocess are detailed further. A further decomposition of the 'prepare OR for surgery' subprocess is rather trivial and is therefore omitted.

![Figure 5: Operation subprocess](image)

### 2.2.4.1 Prepare patient for Surgery

Figure 6 shows the process model of the 'prepare for surgery' subprocess. Each day, between 7 and 9 heart surgeries are performed. The first surgery starts at 07:45, while the other surgery times depend on the duration of the previous surgery. When a patient is scheduled at 07:45, he is awoken in time by a nurse ('verpleegkundige' (VK)), otherwise the patient (together with his family) has to wait until the time at which his surgery can proceed.

![Figure 6: Prepare patient for surgery subprocess](image)
As a preparation for the surgery, the patient is shaved and the medication (determined by the anesthetist in the PPOS subprocess) is administered. The patient is then accompanied by the VK to the preparation room where he will be picked up and accompanied by an anesthetist-VK to the surgery room.

### 2.2.4.2 Surgery

After the patient and operation room are prepared for surgery, the actual surgery can be performed. Figure 7 shows the process model of the CTS surgery subprocess.

The patient is put to sleep using anesthetics and the family of the patient is informed of the start of the surgery. The cardiothoracic surgery itself is not further detailed. During surgery, status changes and scoring information is entered into the hospital information system. This information is used, amongst others, in the monitoring process, in which all ongoing operations are monitored and scheduled. Due to state changes in one operation or because of emergencies, other operations can be postponed or even cancelled. After the surgery has been completed, the patients' family is informed about the course of the surgery.

### 2.2.5 Intensive Care

After the surgery, the patient is moved to intensive care. As explained before, the intensive care is divided in four different types:
- High Care (HC)
- Post anesthesia Care Unit (PACU)
- Intensive Care (IC)
- Medium Care (MC)

The difference between the four types is in the amount of care given to (and required by) a patient. The level of care in PACU is the same as High Care. However, the PACU beds are only available for a maximum of twelve hours (from 10:00 till 22:00 hours). If the patient is not in a stable condition at PACU closure, he is moved to High Care. Every morning, the staff of the ICU discusses the status of each patient staying in the ICU (in High Care, Intensive Care, or Medium Care) and determines which patient can go back to the regular ward (of the responsible unit). This is a separate process that runs in parallel to the CTS process being modeled in this report. The ICU subprocesses (indicated in Figure 8) that are part of the main CTS process, explained in Section 2.1 are rather trivial (containing activities like washing, eating, measuring medical parameters (blood pressure, heart beat, etc.)) and are not modeled in more detail.

Figure 8: The intensive care subprocesses

2.2.6 PostPACU

When a patient was placed in PACU after the surgery, and everything went well during the PACU stay, the patient can be moved back to the CTS ward at Afd6-West (otherwise the patient is moved to High Care). For the first night, the patient is moved to 'postpacu'.
Figure 9 illustrates the tasks performed during the first day after the postpacu night. The heart is monitored for at least another 24 hours. If possible or required, the tubes/drains are removed. The patient is washed and the bed is cleaned. On the first day, depending on the patient condition, it is also possible for the patient to start practicing breathing on his own again. In case a vain has been removed from the leg to be used in the bypass, special socks (called 'steunkousen' or 'support stockings') are applied to support the blood circulation in the leg again. During all these activities, it is also possible for the patient to request for an appointment with the CT surgeon after which this appointment is scheduled. When all these activities have been performed, the patient can leave postpacu and return to the regular ward of Afd6-West, where he will receive the care given by the staff of Afd6-West in their daily post-op routine (post-surgery routine).
2.2.7 Daily Post-Op Routine at Afdeling 6-West

The daily routine following after a patient has returned from the surgery, is presented in the detailed process model in Figure 10. A number of the activities in this process are again subprocess that can be detailed further, e.g., visit patient, post-op visit, ‘wondverzorging’, take measurements, take scans, night shift, etc.

At the start of the day, the medicine to be taken by the patient are prepared and handed out by the VK. After breakfast, the patient can freshen up or take a shower and the wound is cleaned and inspected (‘wondverzorging’). When the beds are made, the patient is offered a drink and a number of measurements (for example, blood pressure, temperature, pulse, and weight) are taken. When a patient will return to another hospital, the discharge usually takes place on day 3. For a bypass operation, usually the discharge from the hospital takes place on day 6 (day 8 for a heart valve replacement operation). One day before the usual discharge day, also a number of scans are taken (ECG, X-Ray, etc) as well as a blood sample. The results of the measurements, scans, and blood sample determine whether a patient can really be discharged and the fiat for discharge is given by the nurse practitioner and arts-assistent during their visit of the patient (so the fiat for discharge is given one day before the actual discharge from the hospital). Also during the visit, tubes and drains that are not necessary anymore are removed.

During the rest of the day, the patient receives more medication, drinks, lunch, diner, and (on Sunday if they are catholic) the ‘communie’. Nearing the end of the day, the patient is visited by the CT surgeon to answer possible questions and give information if requested. The patient itself has to monitor his own condition during the day and report (disturbing) changes to the VK, who can then take action. At the end of the day the night shift starts, which is not detailed any further in this report.
Figure 10: The daily post-op subprocess
2.2.8 Discharge

The patient is discharged from CZE, when he is considered to be in a stable condition. The discharge subprocess consists of only a few activities. The VK has a 'discharge talk' with the patient, in which the patient is explained about the recovery procedure, the living-rules to abide by to expedite the recovery, which medication the patient needs and when to take them, etc. Of course it is an interactive talk and the patient can ask questions about anything related to the CTS surgery and recovery. Afterwards, the patient makes an appointment with the CT surgeon (via the department secretary ('Afd. Secr.')) to talk about the operation. This appointment is usually scheduled six weeks after the discharge from the hospital.

![Diagram of the discharge subprocess]

**Figure 11: The discharge subprocess**
3 Agreements

For the CTS process to 'execute' smoothly, a number of agreements have been made between the involved units and organizations. The agreements have been specified in, so called, Service Level Agreements. We can distinguish between intra-organizational agreements (between the units in CZE itself) and inter-organizational agreements (between (units of) CZE and other hospitals). Note that from a service-oriented point of view, this distinction is not relevant, see next section.

3.1 Intra-Organizational

The units within the Catharina hospital involved in the CTS process are (as modeled in the previous section):

- Cardiothoracic surgery
  - Cardiothoracic Policlinic (CTpoli)
  - Cardiothoracic unit (Afd6-West)
- Operating Rooms
- Intensive Care Unit

The SLAs made between these three organizational units concerns the number of operations to be performed (amongst them the number of heart-surgeries) and the number of beds required (and made available) in the intensive care unit (ICU), amongst which the number of PACU beds required. The result of a SLA meeting between the three units is presented in Appendix 8.1. As can be seen in the appendix, the result is a rather hybrid mix of strategic, technical, and operational agreements. The strategic element concerns the statement that the agreements can only be made final and depend on the overall budgets are approved. The technical element refers to the 'good and stable' planning that is desired, and the operational element is covered by the statement that ICU should accommodate seven to eight CTS patients per day (of which 4 are PACU patients). Figure 12 illustrates the relations between these three types of agreements.
Also shown in Appendix 8.1 is a list of requirements posed by the CTS unit on the ICU. The list contains the patients' minimum conditions that must be satisfied before Afd6-West allows a return of the patient to the postpacu ward at Afd6-West from the PACU care provided by ICU. Such requirements should be included in (and be part of) the SLA created between the CTS unit and ICU.

### 3.2 Inter-Organizational

The CTS process as described above contains a more complicating element (not shown in the process models) in which not the 'own' patients are treated, i.e., patients referred directly to CZE by their general practitioner, but where patients are coming from other hospitals in the area. These patients stay in another hospital and are 'moved' to CZE to undergo the PPOS and surgery, but are moved back to their originating hospital as soon as they have recovered well enough. So, CZE (the CTS unit to be precise) acts as a 'service provider' to these other hospitals.

Between CZE and the other hospitals agreements have been made to be able to treat the patients from these other hospitals. These agreements seem to be rather informal and state the requirements posed by CZE in relation to patient examinations. These requirements are listed as a check list that states what and which examinations a patient must have had before coming to CZE (see Appendix 8.2). In case the requirements are not met, the patient is sent back to his 'own' hospital and the planned heart surgery is postponed. Although such a checklist could be part of a service level agreement, it does not form one on its own. Note: although requirements of CZE towards the other hospitals are explicitly listed (using the checklist), the other way around does not exist: the other hospitals have not explicitly listed the requirements that CZE has to satisfy.
4 Service Oriented View

As explained in the introduction, the XTC project aims to improve reliability in process executions (using ATCs) and to facilitate creating reliability agreements between (units of) organizations (TxSLA). The relevant concepts and their relations are shown in Figure 1. From the process models, shown in Section 2, and the existing agreements presented in the previous section, a service oriented view on the CTS process can be constructed. Such a view, as shown in Figure 13, presents the involved parties and the interactions between the services offered and consumed by those involved parties. From a patient's point of view, the CTS process is offered to him by CZE as a service (the CTS service), with which the patient interacts. The CTS service is a well-defined business function of the hospital: treating patients that have heart problems by performing heart surgery (bypass, heart valve replacement, etc.). The same service is also offered by CZE to other hospitals, although the actual implementation of the service is somewhat different from the CTS service offered to patients directly. The difference lies mainly in the scheduling of the PPOS, hospital admittance, and the length of stay in the hospital, as well as in the number of scans to undergo during PPOS. Within CZE, a number of services can be identified that are part of the CTS service. These services are offered by certain units in the hospital and consumed by other units of the hospital. Figure 13 shows these services involved in the CTS service. The CTS service makes use of the PPOS service offered by the cardiothoracic policlinic (CTpoli) and of the service offered by Afd6-West (called CTS-Ward) in which the patients are admitted to the hospital for a duration of a number of days. During the stay, the surgery (CTS surgery) service, offered by the 'operation rooms' unit, is invoked by the CTS-Ward. Immediately after the surgery service has finished, the required ICU service is invoked by the CTS-Ward. Although the ICU service is invoked by the CTS-Ward, the patient is (of course) moved from the operation room to intensive care; Figure 13 shows the interaction between the existing services, and not the 'flow' of data/resources (patients) between these services. The surgery service, in turn, makes use of one (or more) of the services offered by the intensive care unit (ICU).
According to the service-oriented view approach, the interactions between the involved units should be captured in service level agreements (one for each collaboration between different units). In the currently existing situation, see previous section and appendix 8.1, one SLA has been created between CTS (c.f. CTS-Ward in Figure 13), OR, and ICU. No explicit SLA is created in the case where other hospitals make use of the CTS service offered by CZE, although some requirements posed by CZE are made explicit in the 'checklist' as shown in appendix 8.2.

Figure 13: Service-Oriented View of the CTS process
5 Introducing the XTC concepts in the CTS process

As stated before, two key concepts have been developed in the XTC project: transactional quality of service and abstract transactional constructs [WGV06, WVG07]. This section describes how these two concepts can be applied in the existing CTS process (without changing the CTS process).

5.1 The FIAT attributes

With the transactional quality of service (TxQoS) concept, the level of process execution reliability can be specified in a service level agreement. TxQoS consists of the following four attributes, called FIAT:

1. Fluency: specifies the maximum number of failures in a process execution

2. Interference: specifies what influence a service consumer can exert on the execution of the provider process (e.g., stopping, pausing, and cancelling a process). The timing parameters used to specify when this influence be exerted, are also specified in the interference attribute.

3. Alternation: specifies which alternative process paths exist, that can be taken when a failure in a process execution occurs so that the failure can be circumvented.

4. Transparency: specifies how much detail of the provider process can be seen by a consumer organization. A provider organization usually does not want to expose its internal level process (reasons can be: company secrets, too much detail, etc), but rather provides an abstracted view of this to the outside world, called external level process. Also, a consumer organization usually is not interested in all details of the provider process.

From the CTS process, the agreements, and the discussions with hospital staff, a number of exceptions (or possible points of failure in the process execution) have been identified, that can occur. Using the FIAT attributes in a TxSLA, these exceptions can be stated explicitly as well as the number of times they can occur, and how to 'solve' them. The following list, presents such exceptions and which FIAT attribute can be used to improve the situation and how that can be done:

- Fluency:
  - When an operation is cancelled, it prolongs the stay of the patient with at least one day (which should rather be avoided). The cancellation of an operation can be seen as a breakdown (failure) in the normal process
execution. Using the 'fluency' attribute in the SLA between CZE and other hospitals, it is possible to specify the maximum number of process breakdowns (cancelled operations) for a certain amount of time.

- Fluency (number of cancelled operations) can also be stated in the agreement between the CTS unit and ICU, so that the maximum number of cancelled operations by the ICU can be specified.

- The actual surgery is performed by an operating team, i.e., the operating team performs the surgery service for the CTS unit. Exceptions during the surgery might occur, in which case the CTS surgery might not be performed completely. This can be seen as a breakdown in the surgery service (process). The number of such breakdowns can again be stated in the SLA between the CTS unit and the Operating Team, using the Fluency attribute.

- Interference:
  - During the waiting periods before the patient is admitted to the hospital, the CTS process can be 'interfered' with because of a status change in the patients condition. The status change might require a rescheduling of the patient (emergency surgery or postponement of the surgery). Using the interference attribute in the SLA it can be stated who can interfere in the process, in what way and when.

- Alternation:
  - Suppose the CTS process is in the state in which the surgery is being performed and that, because of an emergency, all beds at the ICU are full. Then, this is an exception to the regular process execution which should be resolved. A solution can be an alternative process path, in which an other patient at ICU (who requires less care) is moved to another unit so that a bed becomes available for the CTS patient. The alternation attribute in a SLA can be used for such circumstances.

- Transparency:
  - When a patient is moved from another hospital to CZE for a cardiothoracic surgery, the medical staff treating this patient in the other hospital can be interested in seeing the progress of the surgery process in CZE. They probably would not like to see much detail of the CTS process (might depend on the role of the person). The global process as shown in Figure 2, is probably detailed enough, or might even be more abstracted from, by seeing 'Intensive Care' instead of its differentiated version (including HC, PACU,
IC, and MC). Using the transparency attribute in the SLA, it is specified how much of the actual CTS process (in all its detail) is shown to the consumer party in the SLA.

- Some time after the CT surgery, the patient will be moved back to Afd6-West. The hospital information system is now configured in a way that only the unit responsible for a patient can see the patient's file. For example, if the patient is in ICU, the CTS unit cannot see the status of the patient. To provide more effective and efficient care, it is necessary that other units (involved in the process) can see what the status or progress of the process is, so that they can anticipate and prepare for the next stages of the process. If, for example, Afd6-West can see or know when to expect a patient or what complications a returning patient has, they can prepare for his arrival and arrange for necessities in advance. Again, this can be stated in the SLA between the units using the transparency attribute.

5.2 Abstract Transactional Constructs

TxQoS increases the reliability by facilitating explicit agreements related to reliability (using the FIAT attributes) in service level agreement(s). The reliability of actual process executions is increased through the support of transaction management. Transaction management has already been used for decades to provide reliability in databases. A transaction is a number of operations (activities or state changes) grouped together with an explicit start and an explicit end. In case an exception (failure) occurs within a transaction, the outcome (or behavior) of that transaction is determined by the transaction model. For example, the transaction model might dictate that all operations in the failing transactions should be undone and then retried. Advances in transaction management make it also applicable in the area of process management, thereby enhancing the reliability in process executions through the support of advanced transaction models. The most well-known and useful transaction concepts are:

- Atomicity: All operations within an atomic transaction must be done or none at all.
- Isolation: The intermediate results from the operations performed within a transaction can not be seen by other transactions.
- Compensation: Semantically undoing the result of the operations within a transaction.
Examples for the CTS process to improve reliability using ATCs are as follows (without changing the actual CTS process itself):

- **Compensation:** In case a patient is scheduled to undergo the operation on a specific day, then he gets special medication on the day of the operation. If the operation then gets cancelled, this needs to be compensated. Compensation in this case takes the form of a talk to the patient (explain the cancellation/postponement) and the administering of the regular medicine (as on a non-operative day). Basically, this means that some extra steps are taken (compensation steps) to bring the process in a state as if it was a regular pre-operation day and the process can restart and continue in the loop of pre-operation daily routines.

- **Isolation:** During the actual surgery, the status of the patient is not visible to any of the other units, nor to the family of the patient. The surgery (sub-)process is thus executed in isolation: only when the surgery process has finished can the status of the patient be seen by other parties. For the same reasons as explained for the transparency FIAT attribute, this is not an ideal situation. It is more effective and efficient if other units can see (some of) the status of the subprocesses executing at other units. Isolation is therefore not a desired attribute for ATCs that support this part of the CTS process.

- **The surgery subprocess consists of a (large) number of activities.** Most of these activities cannot be undone (as they have a physical result on the patient), but might be compensated in case an exception occurs during the surgery. At some point during the operation, it is probably impossible to interrupt (or abort) the surgery and the surgery should be completed in its entirety. This means that the process is not abortable from that moment on. Using suitable ATCs for the process (having the atomicity property), such requirements can be enforced.
6 Advanced opportunities using XTC in CTS

Through the application of the XTC concepts to the CTS process, the reliability of the process is increased. Also, by making the reliability of the CTS process explicit through the FIAT attributes in a transactional service level agreement, the CTS process can be offered as a service to interested parties (as it is offered to other hospitals at the moment). Through the explicit reliability guarantees, patients might compare the CTS service offered by CZE with similar services offered by other hospitals, on the basis of the reliability specifications. To be able to specify a TxSLA, the actual CTS process itself must be supported by ATCs that provide for the actual execution reliability of the process.

Other opportunities become apparent through the service-oriented view, taken on the CTS process. The PPOS can be seen as a service (offered by the CT policlinic) exclusively used by the CTS unit for the CTS process. However, the PPOS could also be seen as a service that could be offered to other units in CZE or to other hospitals are private clinics (that require such a thorough screening process).

The same line of reasoning as for the PPOS, can hold for the anesthetics. Administering the anesthetics can also be seen as a service (now it is included in the surgery service) to be offered to the different surgical units in the hospital. Offering the anesthetics service to other hospitals is most likely not practical, but could conceptually also be done.

Opposite to creating and offering new services, CZE might also consume services offered by other health care providers. For example, in the PPOS a number of scans of the patient are made. These scans could also be made in dedicated (private) clinics, of which the result is send to the CT policlinic to be interpreted. In a more extreme case, the entire scanning and interpretation of these scans can be performed by (outsourced to) a dedicated clinic. Both are situation that are part of the teleradiology service, already offered by commercial clinics [Sch06].

Acknowledgements

For providing detailed information about the CTS process, Frank Verstappen, Ingrid van Vucht, and Dick Koning are acknowledged. Anke Hutzschenreuter is especially acknowledged for providing feedback on a draft version of this report.
7 References


[PIZ08] Inspectie voor de Gezondheidszorg, Vereniging van ziekenhuizen, Nederlands Federatie van Universitair Medische Centra, Orde van Medisch Specialisten; *Prestatie-indicatoren ziekenhuizen, Basisset 2008*. http://www.snellerbeter.nl/prestatie-indicatoren/


8 Appendix

8.1 Service Level Agreements – CTS / OR / ICU

In het SLA gesprek met de functiegroep CTC, OK en ICU is het volgende besproken;
De benutting en bezettingcijfers van 2007 t/m juli zijn goed. Voor 2008 geeft Joost aan
dat de CTC 1800 hartoperaties, 140 longoperatie en 100 scopieen
Dit alles willen ze gaan doen in dezelfde tijd als 2007.
Voor de ICU betekent dit dat deze rekening moeten houden met 7 à 8 patiënten per dag
waarvan 4 PACU’s. dit is ook conform productie 2007
Aangegeven wordt dat het wel van groot belang is dat er een goede en stabiele planning

Translation:

The following has been discussed during the SLA talks with the groups CTS, OR, and ICU;
The numbers of 2007 (until, and including July) concerning use and occupation levels are
good. For 2008, Joost predicts 1800 heart surgeries, 140 lung surgeries, and 100
scopieen. To be done in the same time as was done in 2007.
For the ICU, this means that they will receive 7 to 8 patients per day, of which 4 PACUs.
This is the same as it was in 2007. It is important that a good and stabile schedule is
Requirements from Afd6-West (=CTS) on ICU for PACU patients, i.e., what should the status of a patient be before he should return from PACU to Afd6-West:

*Translation:*

Return to 6-West

If Patient:
- Hemo-dynamically stable
- Very much awake
- Blood leakage < 50 cc (thoraxdrain)
- Not dependent on artificial respiration
- Fiat given by anesthetist

   Return to 6-West
## 8.2 Service Level Agreements – CZE / Other hospitals

### Checklist hartoperatie patiënten Catharina ziekenhuis:

**Naam:** .................................................................

**Geboortedatum:** ............................................................

**Algemeen**

<table>
<thead>
<tr>
<th>Pré-operatief sintom, marcoumar, acty/salicyzuur stoppen volgens afspraak arts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consulten: Longarts } op indicatie arts</td>
</tr>
<tr>
<td>Internist } op indicatie arts</td>
</tr>
<tr>
<td>Neuroloog } op indicatie arts</td>
</tr>
<tr>
<td>Uroloog } op indicatie arts</td>
</tr>
<tr>
<td>KNO arts + } bij een kle mContext, Kaakchirurg met bijbehorende foto's, x- sinus cq x- opg</td>
</tr>
<tr>
<td>X-thorax ( va + dwars, max. 3 maanden oud of een verslag ervan)</td>
</tr>
</tbody>
</table>

**Volledig ECG**

Stollingsonderzoek: bij aanwijzingen voor stollingsstoornissen

**Patiëntenmap Catharinaziekenhuis uitleenen aan de patiënt**

Preoperatieve vragenlijst anesthesiologie in laten vullen door de patiënt

Verpleegkundig anamneseformulier in laten vullen door de patiënt

Indien de patiënt een hartkle mContext krijgt, het desbetreffende boekje geven

De informatie CD-ROM laten zien

Verpleegkundige overdracht schrijven

**Ambulance regelen,**

Familie is op de hoogte van overplaatsing: ja / nee, rijdt mee: ja / nee

**Laboratorium onderzoek volgt in het Catharina ziekenhuis.**

**Evenals verdere voorbereidingen zoals ontharen.**

**Nazorg geregeld, na het ontslag,**

ja / nee

Zo ja, welke zorg:

Bij vragen kan de patiënt contact opnemen met de verpleegkundig consultent CTC

Tel: 040-2399111. Seinnummer 117644

Alle papieren, foto’s(e), film(e), cd-rom, consulten e.d. meegeven aan de patiënt

Na 3-4 dagen na de operatie komt de patiënt in principe weer terug met de ambulance

voor verder herstel tot aan het ontslag.

Alle gegevens + aanzenuwende informatie komen met de patiënt mee terug.