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A flexible Workflow Management System for CAD of Telecommunication Networks

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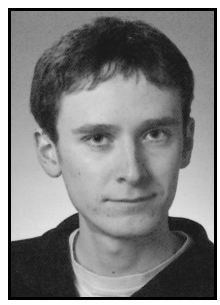

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Abstract

The main challenge in the development of the CANDY Framework, a CAD system for Telecommunication Networks, is integration and interoperability of newly developed and existing design tools under an integrated network CAD workflow. The main problem of many existing workflow management solutions is their heavy-weight approach. A Workflow Management System has to provide an adequate trade-off between sufficient flexibility and consideration of the specifics of project and CAD work. Related approaches like PNML, XPDL, WS-BPEL, ARIS/SAP PI and multiple others exhibit absence of the wished flexibility due to their generality, complexity and/or binding to a specific platform. In contrast, this paper discusses a flexible Workflow Management system for CAD of Telecommunication Networks.

Keywords: project management, workflow management, design methods, CAD, and telecommunication networks.

Elastyczny system zarządzania przepływem dla systemów CAD w sieciach telekomunikacyjnych

Streszczenie

Główne wyzwanie projektu ramowego CANDY dotyczy opracowania systemu CAD przeznaczonego do projektowania sieci telekomunikacyjnych. System ma integrować nowe i istniejące narzędzia do projektowania i ma być interoperacyjny. Głównym problemem wielu istniejących rozwiązań elektronicznego obiegu dokumentów systemów zarządzania jest ich bardzo duże zapotrzebowanie pamięci. Opracowany Elektroniczny System Zarządzania ma odpowiednio równoważyć elastyczność przy uwzględnieniu specyfiki projektu, oraz pracę z systemem CAD. Istniejące rozwiązania, takie jak PNML, XPDL, WS-BPEL, ARIS/SAP PI i wiele innych, wykazują brak pożądanej elastyczności z powodu ich ogólności, złożoności i/lub powiązania z określoną platformą. W artykule omówiony jest elastyczny system zarządzania elektronicznym obiegiem dokumentacji dla programu CAD do projektowania systemów telekomunikacyjnych, który nie ma tych ograniczeń. Przedstawiono koncepcję projektu CANDY oraz podstawy sformalizowanego opisu przepływu zadań w tym projekcie.

Słowa kluczowe: zarządzanie projektem, elektroniczny obieg dokumentów, metody projektowania, CAD, sieci telekomunikacyjne.

1. State-of-the-Art

The CANDY Framework [1-3], a CAD solution for telecommunication networks, can be deployed for solving complex design and optimization problems for networks based on IEEE 802.3, 802.11, 802.16, 802.15.4 as well as EN50173 SCS-standards (constellation, cable routing tasks). The utilized design methodology for wired and wireless local-area networks is intended to solve the optimization problem for overall-costs under performance constraints like data throughput, delay, and jitter. The solution can be obtained using CANDY tools for graph-based geometrical, queuing theory, and event-driven simulation [1, 2]. The central component for tool integration is NDML, the Network Design Markup Language [1 – 3]. NDML is based on XML and provides interoperability with further tools for design, verification and management of wired and wireless TCP/IP-networks like OPNET Gurus, AWE WinProp, NS-2, OMNeT++, Verinec, Netopeer, Ekahau Site Survey, R3FD WiFi Planner etc.

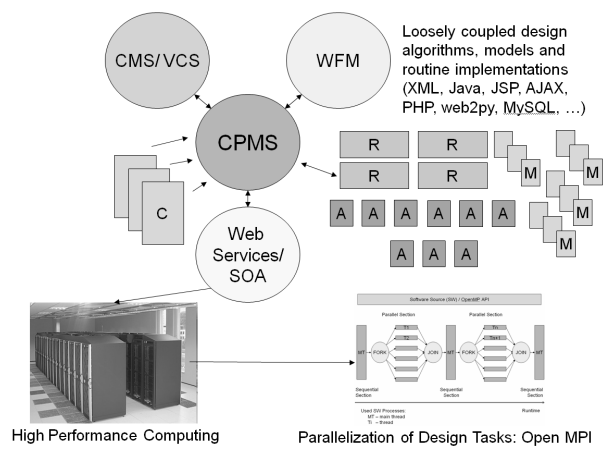

Fig. 1. Project Management within a CAD of Telecommunication Networks
Rys. 1. Schemat zarządzania projektem w systemie CAD przeznaczonym do projektowania sieci telekomunikacyjnych

A Project Management System (PMS) can be positioned as follows (Fig. 1): The PMS integrates properties of Content Management Systems (CMS) as well as Version Control Systems (VCS) and Workflow Management (WFM). The PM software supports consistent document access for multiple clients. One important requirement to a PM system is availability of an efficient Web Service (WS) interface. Web services can be used to delegate computing tasks to high performance computers and computing clusters, e.g. for parallelization of design algorithms (A) and routines (R) of computationally intense tasks (T) or multi-variant analysis [1, 3]. Furthermore, the PM can integrate sets of

loose design routines (R), models (M) and algorithms (A) into the elaborated design WF [3]. The offered Web Service access architecture and computing power offer workflow participants the possibility to start ambitious CAD-jobs and then obtain the results within few minutes [4, 5].

The Workflow Model (s. Sections 3, 4) offered in this paper is based on the general Design Methodology previously discussed in [3], which is able to describe, steer and optimize the design processes and practicable workflows for CAD of Telecommunication Networks. The design methodology is a tuple [1, 3]:

$$\mu = (WF, T, R, M, A, \sigma), \tag{1}$$

where: WF – design workflow, (T,R,M,A) – sets of tasks, routines, models and design algorithms, σ – a defined algebra for (T,R,M,A)-sets.

The algebra σ consists of four regular binary set-theoretical operations and one unary operation on the (T,R,M,A)-sets:

$$\begin{aligned} &UNION: X \cup Y, && CARTESIAN: X \times Y, \\ &MINUS: X - Y, && INTERSECT: X \cap Y, \\ &X^* = CONFIGURATION(X), \end{aligned} \tag{2}$$

where X, Y are the set-operands. The operation CONFIGURATION defines an ordered target set X^* on the source set X. So the physical sense of the operation $T \times M$ must signify "covering of the practicable design tasks by deployed design methods". The following design tasks $T=\{T_i\}$, $i=1,n$ can be used in the scope of telecommunication networks (wired and wireless local-area networks) [1, 2, 6], for instance:

$$\begin{aligned} &T_1 = \{Topo\log y\ Input\}, ...T_{12} = \{Cabling\ System\ Tracing\}, \\ &T_{20} = \{Wireless\ \Pr opagation\ Computing\}, ... \\ &T_{30} = \{Evaluation\ of\ TCP/IP - Infrastructure\}, ... \end{aligned} \tag{3}$$

The given design task set is extensible up to 30 – 60 further tasks, depending on the concrete design object. Former versions of the tools of the CANDY Framework (cp. R-set) exhibit so-called *workflow awareness* [3]. This kind of consideration of CAD-specific project tasks (cp. T-set) matches well to implementation based on the Eclipse Rich Client Platform. However this platform entails a heavy-weight approach in the workflow (WF) and tool integration. Targeted at more easy and loose coupling of design tools and project routines (R-set) a new WF model is offered.

2. Overall Concept of the CANDY Project Management System (CPMS)

The concept for the CPMS can be compared to related approaches [1, 3, 8] based on PNML (Petri Net Markup Language), XPDL (XML Process Definition Language of Workflow Management Coalition), ARIS (Architecture of Integrated Information Systems of SAP Process Integration, in German "Architektur integrierter Informationssysteme"), WS-BPEL (WS-Business Process Execution Language). The mentioned solutions possess some significant disadvantages laying in the surface of:

- more general and complex approach (WS-BPEL);
- relevance for more proprietary solutions;
- binding to a certain platform (e.g. SAP PI);
- heavy-weight approach with insufficent flexibility (WS-BPEL).

The CPMS' core functionality is Workflow Management [7], i.e. the system provides functions for definition and creation of workflows and manages the execution of the defined workflows. The system also offers basic document management in the sense that it provides a central place for storage of project-related data, allowing for data exchange between the involved workflow participants.

The CPMS is conceived as a lightweight solution with web browser based front-end. The application is developed in Python using the web2py framework [8]; it runs on various web servers with Python support and uses the MySQL database. Due to the data abstraction facilities of the framework, adaptation to other common database systems is easy. The CPMS is not restricted to a specific domain, a generic approach is taken. It is targeted at small to medium-sized projects and project groups with workflows involving up to 20 participants and up to 30 – 60 individual activities.

Activities are specified as task definitions, containing a description of the work to be done, information about prerequisites and output documents, supporting software, requirements to the workflow participant and other information. Task definitions are created in XML. Scripts for automated tasks can be written in Python or other languages, corresponding programming interfaces are included with the CPMS.

3. A Workflow Model Formalization

The Workflow Model of the CPMS comprises a control flow model and a data model that describes the handing over of documents and data between the tasks. The control flow model (Fig. 2) allows for sequential and parallel execution of tasks, as well as for definition of conditional branches. It possesses a hierarchical structure [1, 3, 7]:

- A workflow consists of a sequence of steps.
- Each step consists of one or more parallel processes. The execution of individual processes can depend on conditions.
- A process either is an atomic task or a workflow.

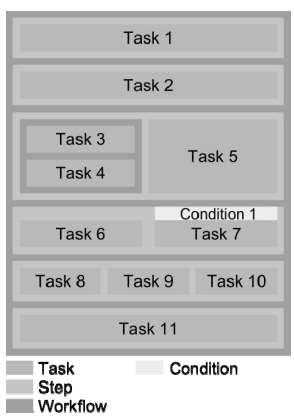

Fig. 2. Workflow – Control flow model
Rys. 2. Model przepływu sterowania zadaniami

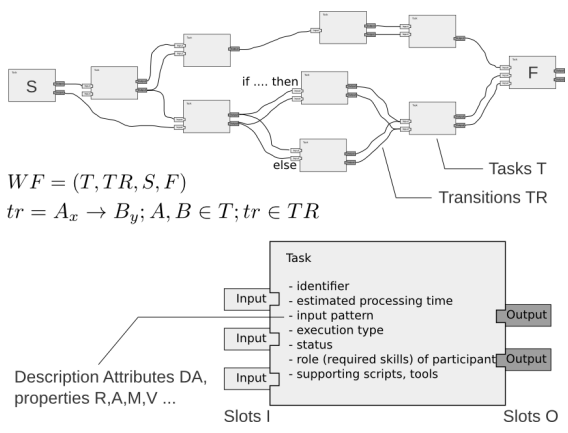

Fig. 3. Workflow – data flow model, formal description
Rys. 3. Formalny opis modelu przepływu danych

The data flow model (see Fig. 3) represents the handing over of documents between the tasks of a workflow. A task definition specifies input and output slots, which describe the prerequisite documents and the output documents that the task will create. These slots are connected by transitions $t = A_x \rightarrow B_y$ indicating that the output slot x of Task A is connected to the input slot y of Task B. A Workflow WF then is a tuple:

$$WF = (T, TR, S, F),$$
$$T = T(DA, R, I, O, D, V), TR \subseteq (T(I) \times T(O)), \quad (4)$$

where: T – set of tasks, TR – self-contained set of transitions, (S,F) – start and final tasks of the WF, × – Cartesian product, DA – description of task attributes, R – associated routine (design application, program file), (I,O) – input and output slots of the task, D – associated input and output document specifications, V – auxiliary validation scripts and/or templates (if any).

4. Creation of Task Types

Task definitions are created offline and comprise (see formula 4):

- A XML task definition specifying task attributes (based on *DA*; see Fig. 6);
- Optionally a directory with a program file and auxiliary files for automated task execution (associated routine *R*, design tools);
- Document specifications (*D*) that describe the input and output slots ((*I*,*O*)-sets);
- A document specification can optionally contain templates and a validation script (*V* element).

An archive containing these files/directories is uploaded to the CPMS server and will be integrated automatically, except for naming conflicts, which have to be resolved manually. Programming interfaces to the CPMS are available for various programming languages and provide functions for:

- Access to input files and creation of output files;
- Access to temporary files;
- Assignment and reading of variables;
- Creation of log entries;
- Evaluation of the location of task-related files;
- Evaluation and setting of task status.

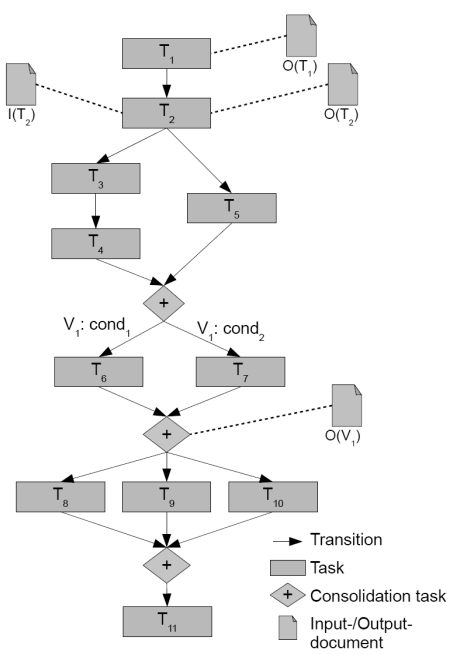

Fig. 4. Workflow – data flow model, formal description
Rys. 4. Formalny opis modelu przepływu danych

5. Results and Conclusions

In contrast to heavy-weight approaches the given paper discusses a flexible Workflow Management System for CAD of Telecommunication Networks.

A design WF model has been elaborated and discussed. The mentioned Workflow Model represents generally a very flexible way to create and steer any design-oriented WF and can be deployed for further CAD solutions. The discussed approach is free of such disadvantages like:

- Binding on a certain platform (e.g. SAP);
- Heavy-weight approach (previous CANDY solutions).

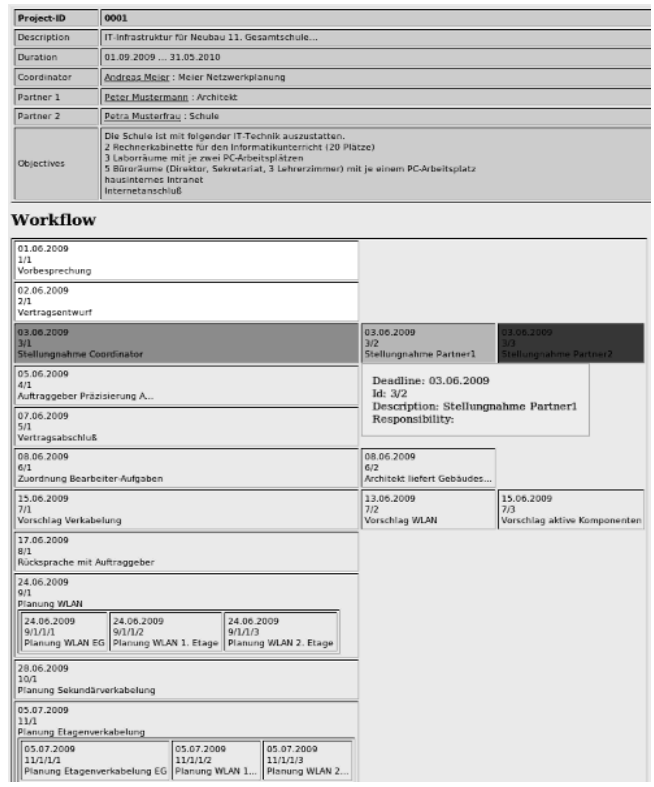

Fig. 5. CANDY Project Management System: Project view
Rys. 5. Okno projektu CANDY sytemu zarządzania projektem

```
<xs:schema>
…
<xs:complexType name="dataSlot">
  <xs:sequence>
    <xs:element name="name" type="xs:string"/>
    <xs:element name="description" type="xs:string"/>
    <xs:element name="documentSpecification" type="xs:string"/>
  </xs:sequence>
</xs:complexType>
<xs:element name="taskType">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="id" type="xs:string"/>
      <xs:element name="name" type="xs:string"/>
      <xs:element name="shortName" type="xs:string"/>
      <xs:element name="description" type="xs:string"/>
      <xs:element name="performerRole" type="xs:string"/>
      <xs:element name="reviewRequired" type="xs:boolean"/>
      <xs:element name="reviewerRole" type="xs:string"/>
      <xs:element name="input" type="dataSlot" minOccurs="0"
                  maxOccurs="unbounded"/>
      <xs:element name="execution" type="executionType"/>
      <xs:element name="script" type="xs:string"/>
      <xs:element name="output" type="dataSlot" minOccurs="0"
                  maxOccurs="unbounded"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
</xs:schema>
```

Fig. 6. CANDY Project Management System: XML Schema task.xsd
Rys. 6. System CANDY zarządzania projektem: XML Schema task.xsd

Some examples of usage are depicted. The developed CPMS integrates properties of CMS and VCS systems [9, 10] and enables consistent and efficient document access for small to medium-sized projects with dynamically created project groups of up to 20 participants and up to 30 – 60 individual workflow activities.

The authors' ongoing researches are dedicated to optimization of the access within the CPMS based on advanced WS-* as well as parallelization of design routines based on threads parallelism (OpenMPI) for computing intensive and complex projects [4, 5, 9, 10].

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