Analytical Availability Assessment of IT-Services

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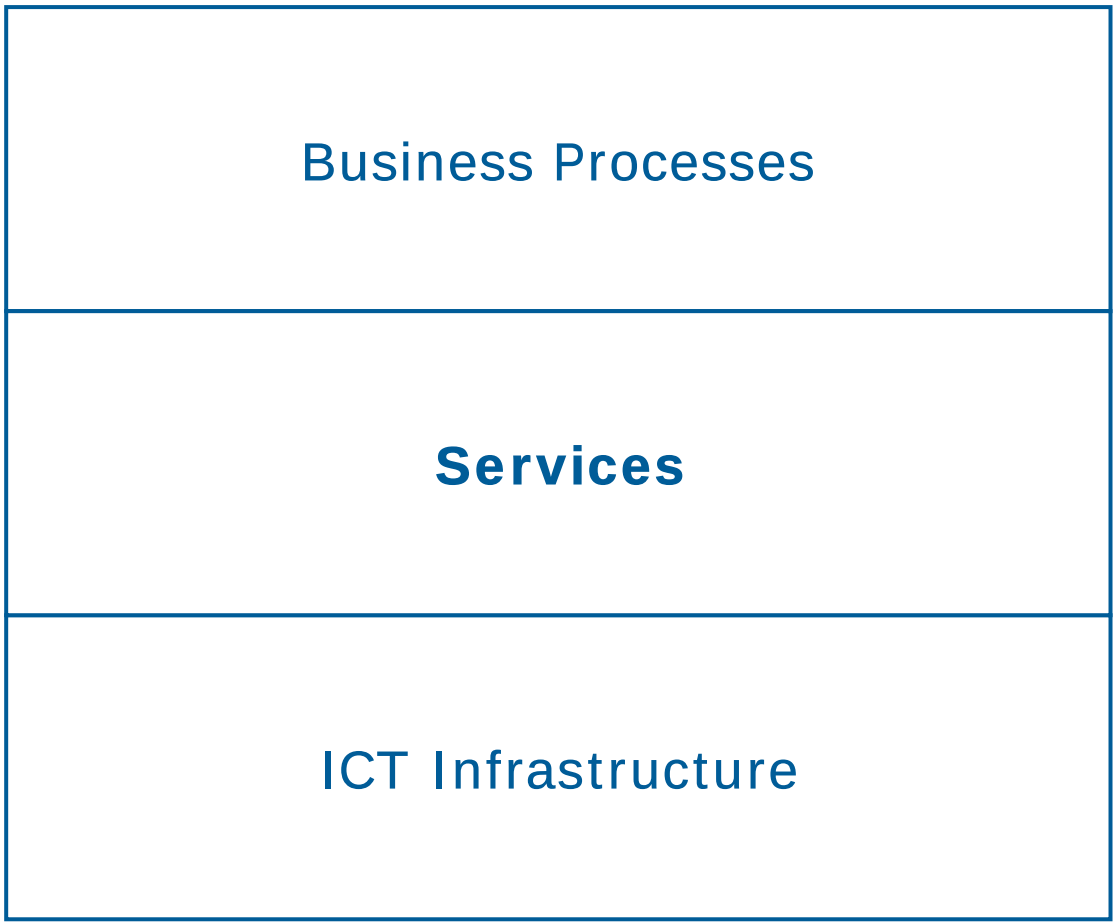
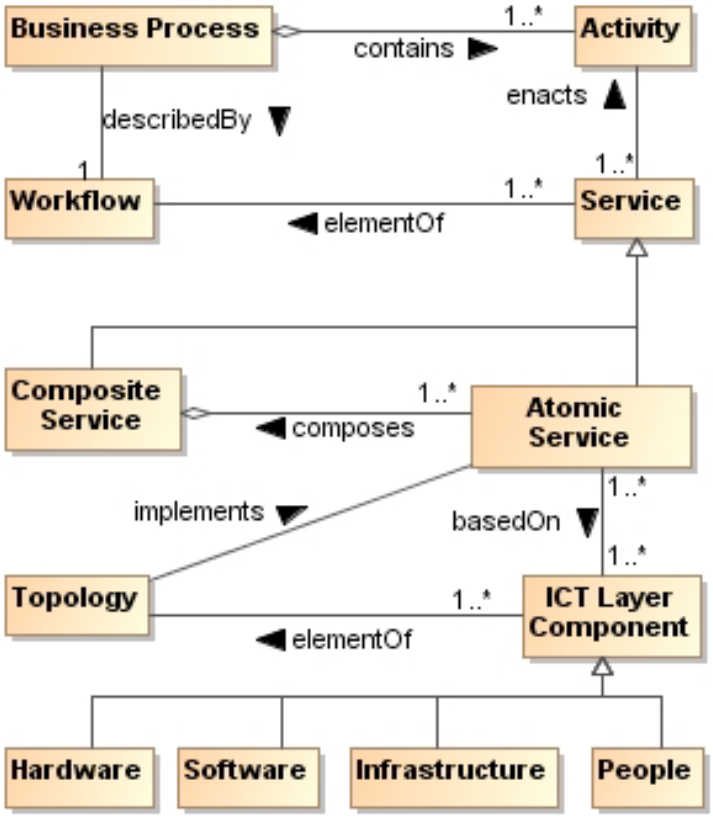
System Layers



The Challenge

- Definition of service-availability:
  - Fault model
  - Types of service availability
- Service availability is the function of the availability of the underlying ICT-layer:
  - Hardware
  - Software
  - Network
  - Supporting infrastructure
  - Personnel
- Determine functional dependency between the ICT-layer availability and service availability using an analytical, model-based approach

Reference Architecture

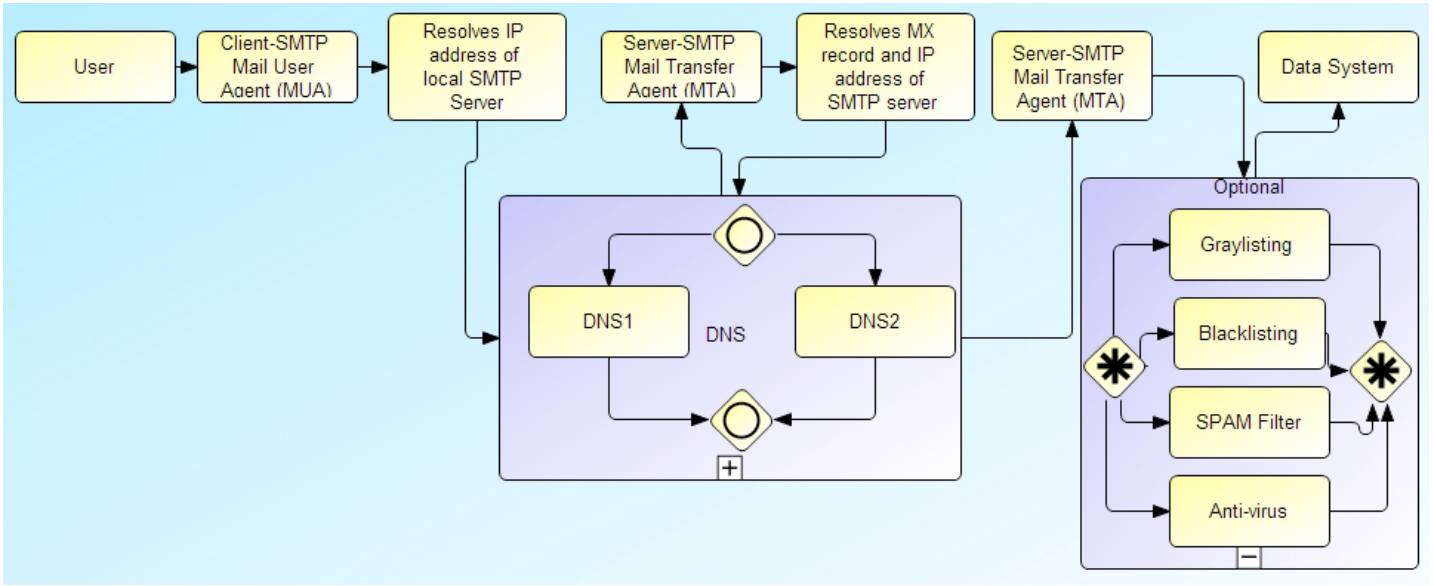


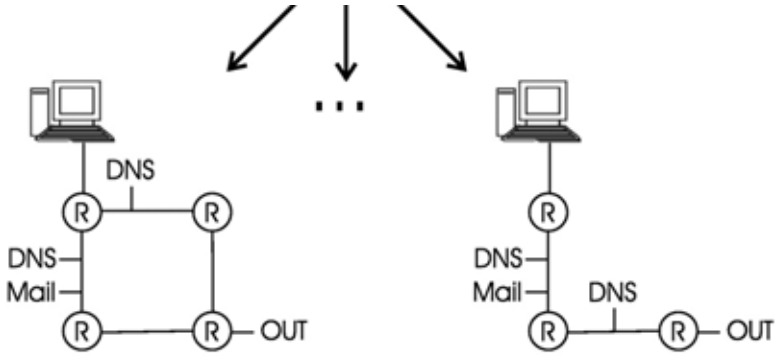
Service-ICT Mapping and Service Availability Assessment

1. A service is described in high-level modeling language (e.g., UML activity diagram, BPMN)
2. A CMDB system collects ICT-layer data (infrastructure graph) which are parameterized (e.g., with MTTF and MTTR)
3. Service activities are mapped onto the infrastructure graph elements, all paths between source and destination for each activity are identified
4. Services of importance are identified
5. The mapped service description is transformed into a formal models (e.g., RBD or FT)

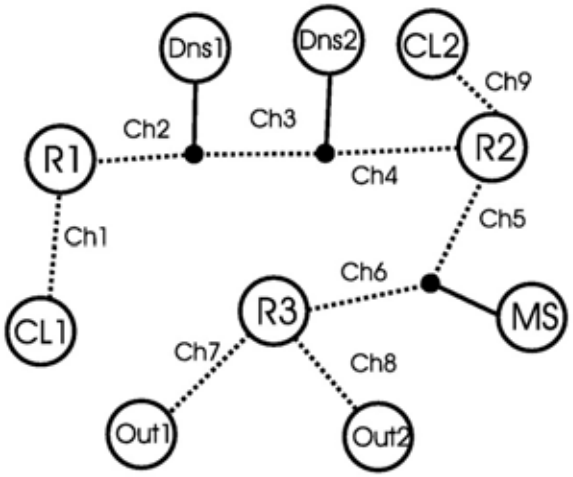
BPMN - Business Process Modeling Notation CMDB - Configuration Management Database

Service Description (BPMN) - E-mail Example





Infrastructure Graph and Parameterization



- CL_i – client i
- R_i – router I
- Ch_2 – communication channel (e.g., Ethernet cable, switch)
- DNS_i – DNS server i
- MS – mail server
- Out_i – outside Internet network connection

Exponential distribution, λ=1/MTTF, μ=1/MTTR

	Router	Channel	DNS	Mail	Client	Out1	Out2
MTTF	9000	4500	4500	4000	4500	135000	5400
MTTR	1	3	2	2	2	4	6

Service-ICT Mapping (1)

- In order to send an email, both clients have to resolve the address of the SMTP server:

$$CL_1 \rightarrow DNS\text{: } (CL_1 \& CH_1 \& R_1 \& CH_2 \& DNS_1) \,\|\, (CL_1 \& CH_1 \& R_1 \& CH_2 \& CH_3 \& DNS_2)$$

$$CL_2 \rightarrow DNS\text{: } (CL_2 \& CH_9 \& R_2 \& CH_4 \& CH_3 \& DNS_1) \,\|\, (CL_2 \& CH_9 \& R_2 \& CH_4 \&\& DNS_2)$$

- A connection with SMTP servers is established:

$$CL_1 \rightarrow MS\text{:} CL_1 \& CH_1 \& R_1 \& CH_2 \& CH_3 \& CH_4 \& R_2 \& CH_5 \& MS$$

$$CL_2 \rightarrow MS\text{:} CL_2 \& CH_9 \& R_2 \& CH_5 \& MS$$

Service-ICT Mapping (2)

- Mail server determines the forward SMTP address:

  $MS \rightarrow DNS: (MS\&CH_5\&R_2\&CH_4\&CH_3\&DNS_1) \parallel (MS\&CH_5\&R_2\&CH_4\&DNS_2)$

- Mail server forwards the email to the out connection:

  $MS \rightarrow OUT: (MS\&CH_6\&R_3\&CH_7\&OUT_1) \parallel (MS\&CH_6\&R_3\&CH_8\&OUT_2)$

- For successful service execution, the steps have to been executed serially:

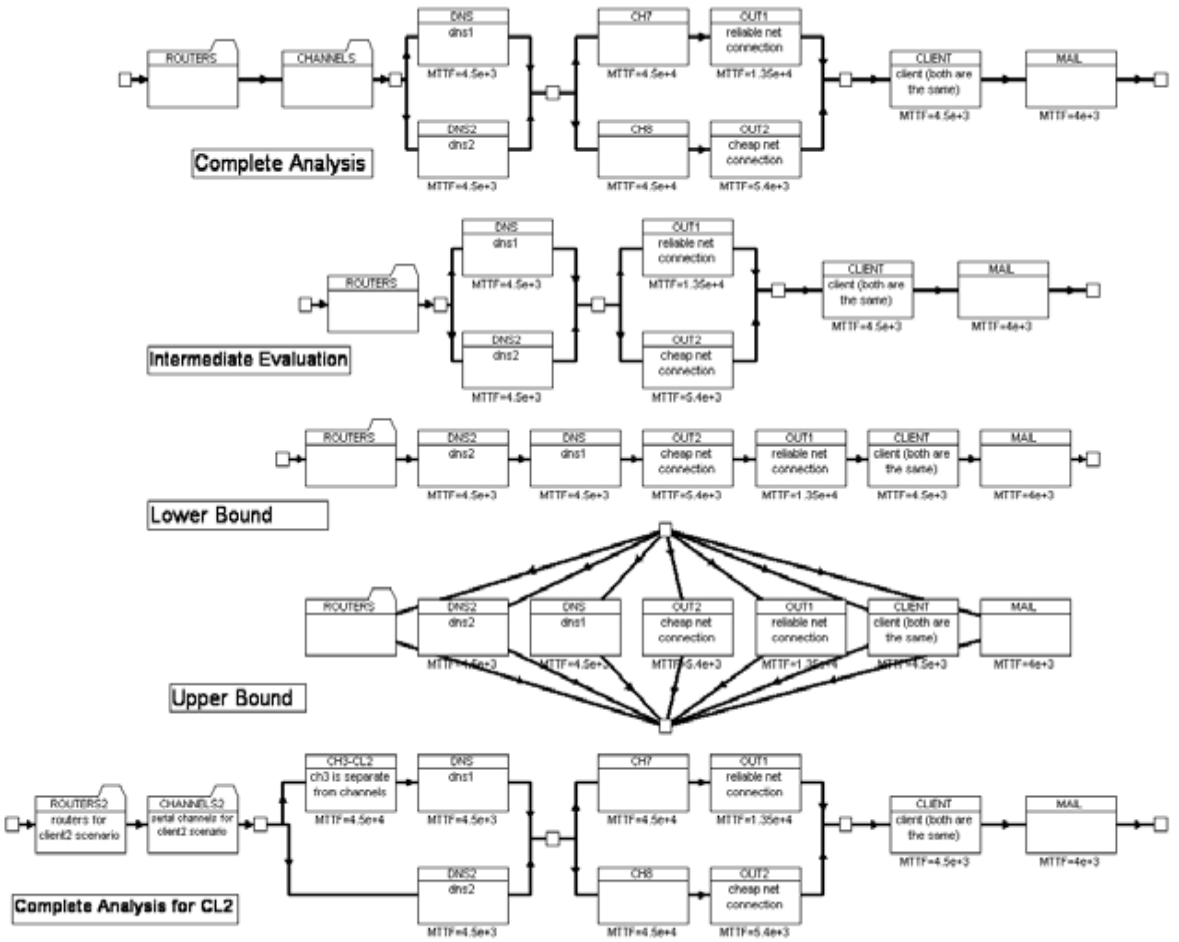
  $CL_1: (CL_1 \rightarrow DNS)\&(CL_1 \rightarrow MS)\&(MS \rightarrow DNS)\&(MS \rightarrow OUT) =$

  $CL_1\&MS\&R_1\&R_2\&R_3\&CH_1\&CH_2\&CH_3\&CH_4\&CH_5\&CH_6\&(DNS_1 \parallel DNS_2)\&(CH_7\&OUT_1 \parallel CH_8\&OUT_2)$

  $CL_2: (CL_2 \rightarrow DNS)\&(CL_2 \rightarrow MS)\&(MS \rightarrow DNS)\&(MS \rightarrow OUT) =$

  $CL_2\&MS\&R_2\&R_3\&CH_9\&CH_4\&CH_5\&CH_6\&(CH_3\&DNS_1 \parallel DNS_2)\&(CH_7\&OUT_1 \parallel CH_8\&OUT_2)$

Model Generation



Availability Assessment (1)

- User-perceived service availability:

	Client 1	*Client 2*
MTTF	1060	1280
MTTR	1.79	1.83
A	0.9983	0.9985

- Total service availability $A_s = \sum_{i=1}^{n} A_i \cdot u_i$

u_1	u_2	A_s
0.5	0.5	0.99846
0.6	0.4	0.99843
0.9	0.1	0.99834
0.1	0.9	0.99855

u_i – utilization factor ($\sum_i u_i = 1$)

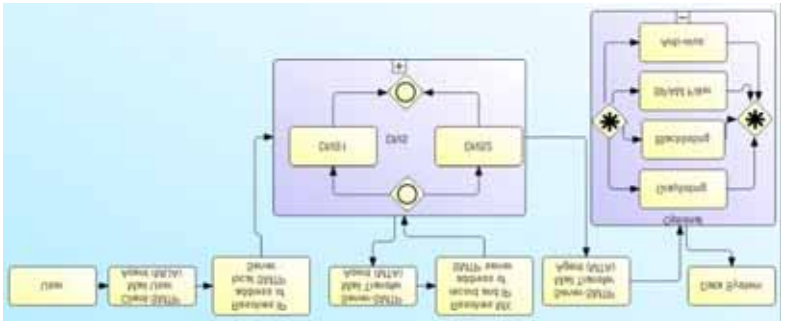
Availability Assessment (2)

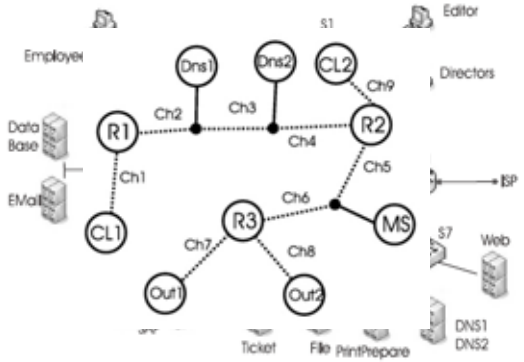
- Incomplete service description or network topology
  - Lower bound: $CL\&MS\&DNS_1\&DNS_2\&R_1\&R_2\&R_3\&OUT_1\&OUT_2$
  - Upper bound: $CL \,||\, MS \,||\, DNS_1 \,||\, DNS_2 \,||\, R_1 \,||\, R_2 \,||\, R_3 \,||\, OUT_1 \,||\, OUT_2$
  - Intermediate: $CL\&MS\&(DNS_1 \,||\, DNS_2)\&R_1\&R_2\&R_3\&(OUT_1 \,||\, OUT_2)$

	Client 1	*Client 2*	*Lower*	*Intermediate*	*Upper*
MTTF	1060	1280	662	1240	6.1e+22
MTTR	1.79	1.83	2.37	1.59	0.293
A	0.99834	0.99868	0.99643	0.99872	1 - 3.5e-24

- Availability data about ICT-layer are not known:
  - Qualitative parameterization
  - Quantitative parameterization

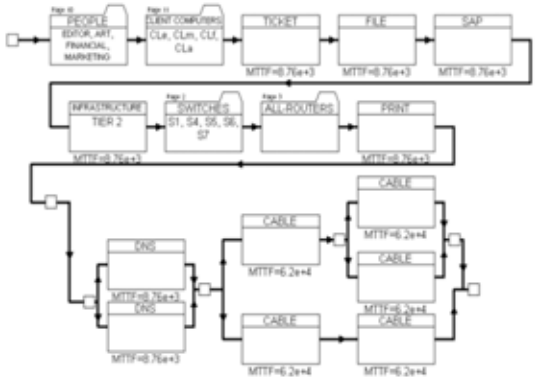
The Complete Process at a Glance





	Client 1	Client 2
MTTF	1060	1280
MTTR	1.79	1.83
A	0.99834	0.99858

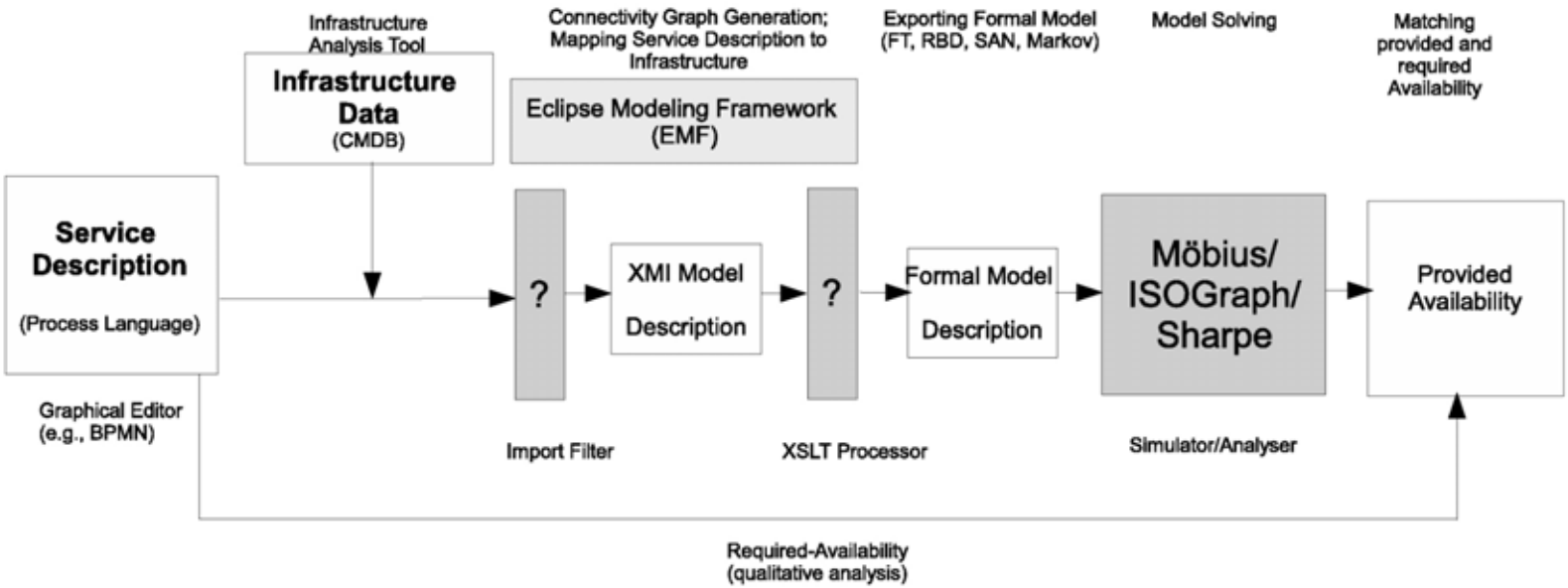
u_1	u_2	A_s
0.5	0.5	0.99846
0.6	0.4	0.998436
0.9	0.1	0.99834
0.1	0.9	0.998556



CL_1: $(CL_1 \rightarrow DNS)\&(CL_1 \rightarrow MS)\&(MS \rightarrow DNS)\&(MS \rightarrow OUT) = CL_1\&MS\&R_1\&R_2\&R_3\&CH_1\&CH_2\&CH_3\&CH_4\&CH_5\&CH_6\&(DNS_1 \| DNS_2)\&(CH_7\&OUT_1 \| CH_8\&OUT_2)$

CL_2: $(CL_2 \rightarrow DNS)\&(CL_2 \rightarrow MS)\&(MS \rightarrow DNS)\&(MS \rightarrow OUT) = CL_2\&MS\&R_2\&R_3\&CH_9\&CH_4\&CH_5\&CH_6\&(CH_3\&DNS_1 \| DNS_2)\&(CH_7\&OUT_1 \| CH_8\&OUT_2)$

Tool's Architecture



Application Areas

- Technical
  - Assessment of existing services and infrastructures
  - Monitoring the infrastructure and reacting to changes
  - Predicting the impact of changes on availability (simulation)
  - Weak spots and single point of failure identification
  - Building block for availability optimization

- Business
  - Reducing missed opportunities
  - Return on investment analysis
  - SLA parameterization
  - Risk analysis
  - Enterprise availability certification

Summary and Open Issues

- Service-ICT mapping and automatic model generation are the cornerstone of our approach
- Independence of the formal availability model
- Capturing not only HW/SW but also supporting infrastructure (e.g., power supply, organization, physical security) and personnel
- Next (big) step: **business process availability**

  N. Milanovic, B. Milic, M. Malek: *Modeling Business Process Availability,* IEEE International Workshop on Methodologies for Non-functional Properties in Services Computing (MNPSC), Hawaii, July 2008
- Open issues:
  - ICT-layer components' parameterization
  - Richer model output (e.g., Markov chains, SANs) required for interval availability computation
  - Need for field data (services, ICT, parameters, topologies,…)