Structural Analysis

Components And Services Model

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Lecture Summary

1. Components and Services Model

2. Conclusions

Components and Services Model

Components and Services Model

Why do we need the Components and Services models?

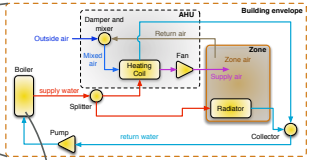
- To **organise knowledge** of the system (nominal behaviour) in a **hierarchical** way
- To allow for **fault propagation** and **effects**, and **root causes analysis** (see next lecture)

Components and Services Model

An example from Smart Buildings

system

sub-system



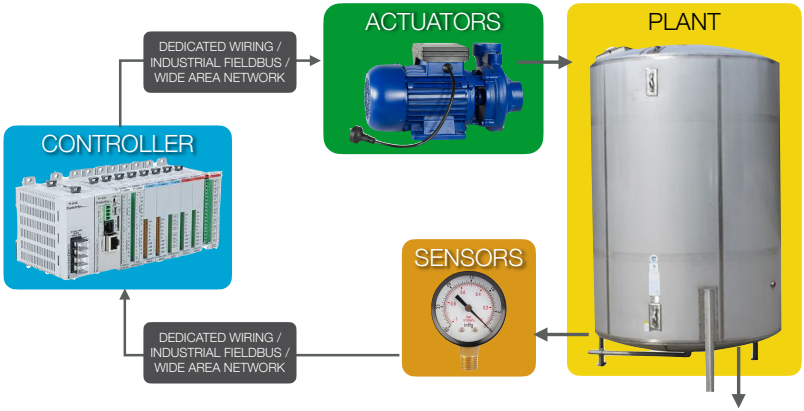
component

$$\begin{cases} \dot{T}_{sw} & = (c_w \rho_w V_B)^{-1}(P_B + c_w w_B(T_{rw} - T_{sw}) \\ & \quad + h_B A_B (T_B - T_{sw})) + \chi_B \\ m[T_{sw}] & = T_{sw} + \xi_B \end{cases}$$

behaviour (dyn. eq.)

Components and Services Model

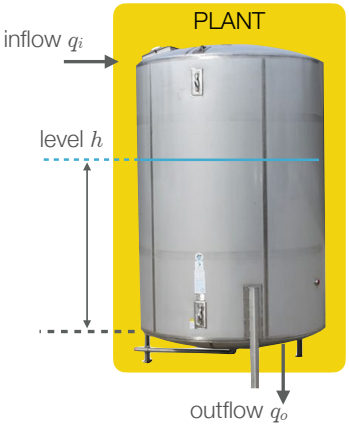
Let us recall the tank example



Components and Services Model

The tank itself is a component

- **Components** provide **services**
- A **tank integrates** inflow minus outflow to **produce** a stored mass $\Rightarrow$ a level h
- It **requires**: a vessel, an input and an output pipe
- A tank will **always provide** such service, if required resources are connected and healthy (i.e. no electric power or control commands needed)



Components and Services Model

The tank itself is a component

- A **service** s is described by a **6-tuple**

$$s = (\text{cons}, \text{prod}, \text{proc}, \text{rqst}, \text{enable}, \text{res})$$

$$\text{cons} = \{q_i,\ q_o\}$$

$$\text{prod} = \{h\}$$

$$\text{proc} = \left\{\dot{h} = q_i - q_o,\ h = \int \dot{h} dt\right\}$$

$$\text{rqst} = \{1\}$$

$$\text{enable} = \{1\}$$

$$\text{res} = \{\text{vessel}, \text{pipes}\}$$

Components and Services Model

Services come in different versions

- For example, an **electric multimeter** offers different **voltage measurement services**
- They differ according to measurable **range**, **resolution** and **accuracy**

Components and Services Model

Availability of services depends on component use mode

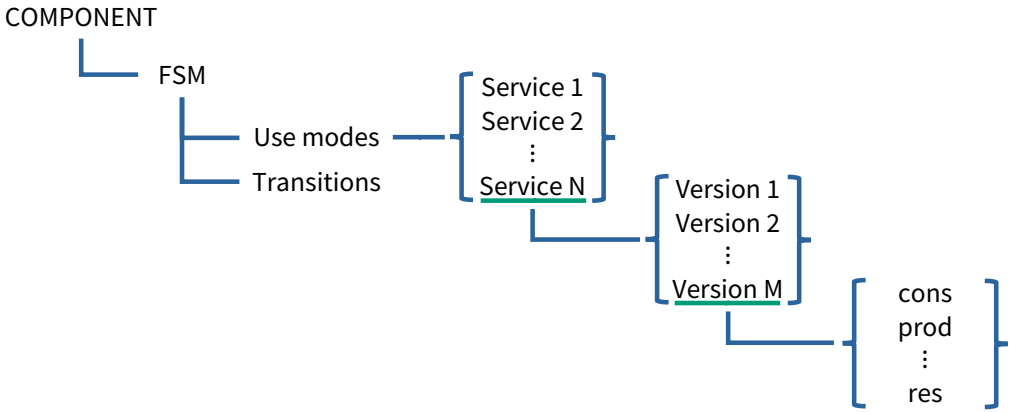
- For example, a wireless speaker can have the following use modes:

  { *off, disconnected, pairing, connected* }

- The service ***playing music*** is available only in ***connected*** mode

Components and Services Model

General component model



Mogens Blanke et al. *Diagnosis and fault-tolerant control*. Vol. 2. Springer, 2006, Ch.4

Components and Services Model

General component model

$$< \textit{component } k > \;::=\; < \textit{state transition graph } G(M(k), \tau(k), m^0(k)) >$$

$$\begin{aligned}
< M(k) > \;::=\; & < \textit{set of use-modes } \{m_i(k), i \in I_m(k)\} > \\
< \tau(k) > \;::=\; & < \textit{set of transitions } \{\tau_{ij}(k), \quad i,j \in I_m(k)\} > \\
< m^0(k) > \;::=\; & < \textit{initial use-mode} > \\
< \textit{use-mode } m_i(k) > \;::=\; & < \textit{set of services } S_i(k) \subseteq S(k) > \\
< \textit{service } s_l(k) > \;::=\; & < \textit{pre-ordered versions} \\
& \quad \left\{ s_l^j(k), \quad j \in J(s_l(k)) \right\} > \\
< \textit{version } s_l^j(k) > \;::=\; & < \textit{consumed vars } cons_l^j(k), \\
& \quad \textit{produced vars } prod_l(k), \\
& \quad \textit{procedures } proc_l^j(k),\ \textit{request } rqst_l(k), \\
& \quad \textit{activation cond. } activ_l^j(k), \\
& \quad \textit{hardware and software resources } res_l^j(k) > \\
< \textit{transition } \tau_{ij}(k) > \;::=\; & < \textit{condition } c_{ij}(k),\ \textit{origin } m_i(k), \\
& \quad \textit{destination } m_j(k) > .
\end{aligned}$$

Mogens Blanke et al. *Diagnosis and fault-tolerant control*. Vol. 2. Springer, 2006, Ch.4

Components and Services Model

How do we use components and services models?

- For **fault diagnosis**
  - Assuming components can be either **healthy** or **faulty** $\Rightarrow$ **root cause analysis** and **propagation analysis**
  - See next lecture on FTA and FMEA
- For **fault accommodation** via **switching** of hardware redundant components
- Remember the example from the Mars landing from lecture 1?

Conclusions

Conclusions

In this lecture we covered

- **Components and services model**

Next lecture: **FTA (Fault Tree Analysis) and FMEA (Fault Modes and Effects Analysis)**

Conclusions

Thank you for your attention!

For further information:

Course page on **Brightspace**

or

our **MS Team**