Accountability, Responsibility and Robustness in Agent Organizations

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Multiagent Organizations (MAO) in a few words

- **MAOs**: strategies for decomposing complex organizational goals into simpler **sub-tasks**, allocating them to **roles**.
- Current models target open systems by allocating and enforcing rights and duties to agents about the tasks to realize.
- Agents' activities are choreographed by issueing obligations.

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- **Agents**: by adopting roles agents execute the corresponding tasks in a distributed, coordinated, and regulated fashion.
- Each **agent**:
  - carries out part of the organizational goal,
  - depends on the **collaboration** of others to perform its task.

Agents lose sight of the overall process

- They are focussed on the achievement of the assigned sub-goals
- Ignore the place of their goals in the big picture
- Who should give restitution to whom?
- Who is interested in my activities ("*stakeholders*")?

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2. When agents fail, the interested parties have no explicit mechanism for sorting out what occurred, for a redress

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Goals achieved but no proof

- Agents who enter the organization are under the regulation of norms, that stipulate their rights and <u>duties</u>
- However, there is no guarantee that they will provide the **accompanying proofs**, that are induced by their assigned responsibilities.

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Need of introducing some explicit representation of some **relationships** agents have with the others, their mutual "dependences", and, more broadly, of the dependence of the organization on its members for what concerns the *realization of the business process*.

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We need a different kind of relationship

An agreement between the parts, respecting a specification inside an organization, whereby the **legitimacy** for one agent to ask information about a subgoal is accepted by **both** the involved agents

We resort on the notions of **responsibility** and **accountability**.

Accountability

(Dubnick and Justice, 2004)

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(Grant and Keohane, 2005)

"Accountability presupposes a relationship between power-wielders and those holding them accountable where there is a general recognition of the **legitimacy** of (1) the operative standards for **accountability** and (2) the authority of the parties to the relationship (one to **exercise particular powers** and the other to **hold them to account**)."

As a consequence, accountability is **grounded on perceived/assumed responsibility**, deriving from **recognition of legitimacy** of exercising some power, and of the claim-right to hold the responsible to account.
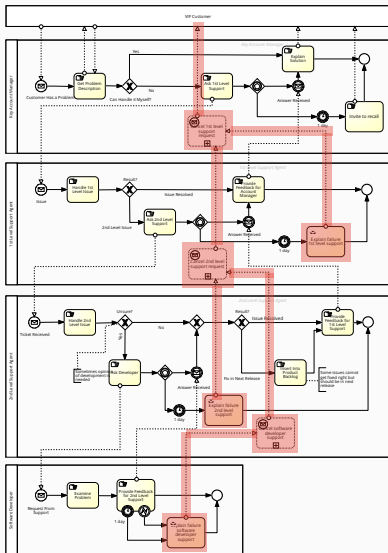
Accountability and Robustness

- **Accountable software**: software that, under given conditions, provides account of what was achieved or what went wrong.
- System results to be **robust**, that is capable **to keep on working** within **acceptable standards** despite something abnormal occurs.

Exception handling

Exception handling as straightforward special case of accountability, where the agents have the agreement that the account-taker is **always** interested in **feedback**, on occurrence of some exceptions. Thereby, the account-giver proactively provides such feedback **without waiting for a request**

- Exception specification
  mechanism captures the
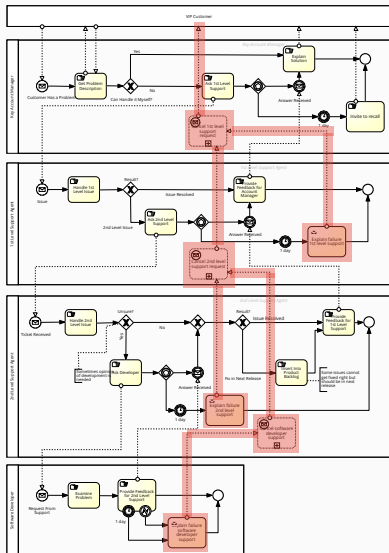 way in which a process is
  interested into another

Exception Handling: a special case of accountability

- Exception specification mechanism captures the way in which a process is interested into another

- A process can react to abnormal events (exceptions), possibly encompassing contextual information provided by others in their decision processes

Exception Handling

- The driver of such a process is the attempt to execute up to the preset standards, possibly through self-regulation, by adapting either the execution or the organization itself

- This process heavily relies on the accounts that the involved agents are expected to produce.

Agent organization

A process being collectively executed by a number of agents. Agents produce and answer to institutional events, and need to coordinate to accomplish the organizational goal.

ARFIN organization

A MAO that includes: an **accountability specification**, a **responsibility distribution**, an **accountability fitting**, and some **norms**.

JaCaMo + A/R

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Such an extension provides organizations with an additional infrastructure that captures who **should** give account to whom for certain states of the organization, and who **can** ask for such feedbacks.

Specifying accountabilities

Accountability $A(x, y, r, u)$

x, the account-giver, is accountable towards y, the account-taker, for the condition u when the condition r (*context*) holds.

Accountability specification

It is a set **A** of <u>accountabilities</u> $A(x, y, r, u)$.

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Accountability is grounded on control and expectation:

- expectation is naturally conveyed with the accountability itself;
- (knowlegde) control is recursively verified on the structure of u: x controls u either directly (it is in position of causing u) or indirectly by relying on accountabilities.

Specifying responsibilities

Responsibility specification

A responsibility specification $R(x, q)$ expresses an expectation on any agent playing role x on pursuing condition q (x is entitled and should have the capabilities of bringing about q).

Responsibility assumption: for playing role x an agent should declare to accept to be considered in the position of causing q.

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R denotes a responsibility distribution, that is a set of responsibility assumptions.

Accountability Fitting $R \rightsquigarrow \mathbb{A}$ ("R fits $\mathbb{A}$")

Given:

- $\mathbb{A}$: a set of accountability specifications;
- **R**: a responsibility distribution;

We say that $\mathbf{R} \rightsquigarrow \mathbb{A}$ when $\exists \, \mathbf{A} \in \mathbb{A}$ such that $\forall \, A(x, y, r, u) \in \mathbf{A}$, $\exists \, R(x, q) \in \mathbf{R}$ such that, for some actualization $\widehat{q}$, $(u/r)/\widehat{q} \equiv \top$.

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Given R$(x, a \cdot b \cdot c)$, A$(x, y, d \cdot e, d \cdot a \cdot c)$,
q is $a \cdot b \cdot c$, r is $d \cdot e$, u is $d \cdot a \cdot c$,
then $(u/r)/\widehat{q}$ is $(d \cdot a \cdot c)/(d \cdot e)/(a \cdot b \cdot c)$.

Intuitively …

Accountability fitting captures a properly defined organization that is guaranteed to properly distribute responsibilities.

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$\mathbf{R} \rightsquigarrow \mathbb{A}$ provides a specification the agents **must explicitly conform to**, when enacting organizational roles.

Accountability Fitting with exceptions

Given a set of events $\mathcal{U}$, let $\mathcal{E}$ be a set of exceptional events, that is, $\mathcal{E} \cap \mathcal{U} = \emptyset$ and each event $e \in \mathcal{E}$ is complementary to possibly many events in $\mathcal{U}$.

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- An expression u is *touched* by an exception $e \in \mathcal{E}$ if for at least one event w occurring in u, $(w, e) \in \mathcal{F}$.
- An accountability relationships $A(x, y, r, u)$ is *touched* by the occurrence of event e when w occurs in u and $(w, e) \in \mathcal{F}$.

Compliance with exceptions

Let $[\mathbf{R} \rightsquigarrow \mathbf{A}]_{\mathcal{F}}$ be an accountability fitting characterized by $\mathcal{F}$. An ARFIN organization is compliant with $[\mathbf{R} \rightsquigarrow \mathbf{A}]_{\mathcal{F}}$ if, whenever $A(x, y, r, u) \in \mathbf{A}$ is touched by an event $e \in \mathcal{E}$, an account about u is requested to x by default.

Complementing a functional decomposition with an accountability fitting with exceptions $[\mathbf{R} \rightsquigarrow \mathbf{A}]_{\mathcal{F}}$ turns an organization (implemented in JaCaMo) into a particular kind of ARFIN organization that considers **abnormal situations explicitly**.

- R(*site preparer*, site_prepared) ∈ **R**
- A(*site preparer*, *manager*, ⊤, site_prepared) ∈ **A**

Abnormal situations/exceptions

Let us suppose the site preparer *agent may fail* because of (1) missing materials or (2) bad weather.

The building house example

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Let us suppose the site preparer *agent may fail* because of (1) missing materials or (2) bad weather.

- *Site preparer* is *touched* by the two exceptional events *missing_material* and *bad_weather*.
- Thus (*site_prepared*, *missing_material*) ∈ $\mathcal{F}$ and (*site_prepared*, *bad_weather*) ∈ $\mathcal{F}$.

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$[\mathbf{R} \rightsquigarrow \mathbf{A}]_{\mathcal{F}}$ characterizes what kinds of exceptional events should be reported and to who.

The building house example

- Extending the functional decomposition by **enriching goal specifications** with the list of the respective relevant exceptional events that could thwart goal achievement.

- The responsible agent will be asked to **report** either the successful achievement or the **exception causing the failure**.

```xml
1   <functional-specification>
2
3    <scheme id="build_house_sch">
4
5     <goal id="house_built">
6      <plan operator="sequence">
7       <goal id="site_prepared" ttf="20 minutes">
8        <exceptions>
9         <exception id="missing_material" />
10        <exception id="bad_weather" />
11       </exceptions>
12      </goal>
13      <goal id="floors_laid" ttf="25 minutes">
14       <exceptions>
15        <exception id="bad_weather" />
16        ...
17       </exceptions>
18      </goal>
19      <goal id="walls_built" ttf="40 minutes" />
20      ...
21     </plan>
22     <catch>
23      <goal id="weather_emergency" handles="bad_weather">
24
25       <plan operator="..."> ... </plan>
26      </goal>
27      <goal id="materials" handles="missing_material">
28       <plan operator="sequence">
29        <goal id="materials_got" ttf="10 minutes" />
30        ...
31       </plan>
32      </goal>
33     </catch>
34    </goal>
35
36     ...
37
38    </scheme>
39
40   </functional-specification>
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The building house example
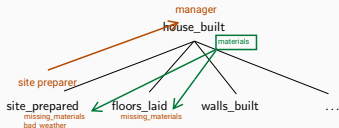
- The specification includes which **handlers** will be activated to tackle the *abnormal situations* (*exception handlers*).

- Handlers are modelled as goals to be achieved in alternative to the failed one (the goal of the agent who receives the exception).

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Conclusions

- Robustness in software systems is "the ability of a software to keep an 'acceptable' behavior [...] in spite of exceptional or unforeseen execution conditions (such as the unavailability of system resources, communication failures, invalid or stressful inputs, etc.)."

- Accountability is a **non-functional requirement** of a software system, that has a positive impact on **system robustness**, since it captures an **infrastructure** for analysing the organization's performance and take action if deemed necessary

- Beyond exceptions, accountability is an enabler for organization **adaptation**, both in **structure** and in **strategies**

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