Adaptive Processes in Disaster Management

Formal Approaches to Business Processes and Web Services @ ATPN2007
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State of the Art in Disaster Management

regulation no 34
• if the water level rises above 4m at point X
• then water blocking measures must be taken

Fire brigade
• if alerted
• we get sand and bags,
• fill sandbags and
• then build a barrier

fail-scenario (infrequent)
• if sand is not available,
• get a different barrier
• and use it
STATE OF THE ART IN DISASTER MANAGEMENT

- **case studies**
  - GeoForschungsZentrum Potsdam ("Taskforce Earthquake")
  - Civil protection authorities in Brandenburg
  - Technisches Hilfswerk
State of the Art in Disaster Management

- disaster management plans, detailed regulations
- laws, regulations, ...
- in-field experiences, “the way we always do”
- common sense, acting in the big picture, command-level experience
State of the Art in Disaster Management

disaster management plans, detailed regulations

laws, regulations, ...

implicit knowledge

Can you adapt to that situation?

What happens if this message is not received?

common sense, acting in the big picture, command-level experience

implicit knowledge
Outline

- requirements for processes in DM
- solve by combining models
- modeling adaptive processes
- outlook
Different Views on Behavior

Constraints

to be obeyed by everyone

Petri net
process models
single person/small group

Partial-ordered runs
scenarios
anti-scenarios
behavior across groups
Different Views on Behavior

- requirements for WFs in DM
- solve by combining models
- modeling adaptive processes
- outlook

Petri net

process models

single person/small group

adapt behavior

Partial-ordered runs

scenarios

anti-scenarios

behavior across groups
Combining Petri Nets and Scenarios

Fire Brigade Petri Net

Scenario specified in head quarter
Combining Petri Nets and Scenarios

Fire Brigade Petri Net

- Start
- Alert

Sand Needed
- Call Sand
- Call Bags

Awaiting Sand
- Get Sand
- Get Bags

Sand Available
- Fill Bags

Barrier Available
- Place Barrier

Final

Gravel Pit

- Sand Needed
- Sand Called

Awaiting Sand
- Not in Time

Sand Not Available
- Check Req
- Notify

Truck Not Available

Warehouse

- Call WB

Awaiting WB
- Get WB

WB Called
- WB Available
- Vehicle Available

Delivering
- Deliver WB

WB Available
- Deliver

Vehicle Available

Hot Scenario - Imperative

Scenario specified in head quarter
Combining Petri Nets and Scenarios

Fire Brigade Petri Net

start
alert
sand needed
reduce
bags needed
awaiting sand
get sand
got bags
sand available
fill bags
barrier available
place barrier
final

fire brigade

sand needed
call sand
awaiting sand
get sand
awaiting bags
get bags
sand available
fill bags
barrier available
place barrier
final

adapt behavior

gravel pit

sand called
call sand
not in time
not in time
sand not available
notify
truck not available

warehouse

check requ.
call WB
awaiting WB
get WB
WB called
WB available
check requ.
vehicle available
deliver WB
delivering

hot scenario - imperative

Scenario specified in head quarter
Combining Petri Nets and Scenarios

Unfolding of the net

- **Start**
  - **Alert**
  - **Sand needed**
    - **Call sand**
    - **Call bags**
    - **Awaiting sand**
    - **Awaiting bags**
    - **Sand available**
      - **Fill bags**
      - **Barrier available**
        - **Place barrier**
        - **Final**
      - **Bags available**
    - **Sand not available**
  - **Cold**
    - **Sand needed**
      - **Call sand**
      - **Awaiting sand**
      - **Not in time**
    - **Sand not available**
  - **Hot**
    - **Awaiting WB**
    - **Barrier available**
      - **Place barrier**
    - **Final**
Optional Extension of the Unfolding

start

sand needed

sand needed

call sand

call bags

awaiting sand

awaiting bags

get sand

get bags

sand available

bags available

fill bags

barrier available

place barrier

final

sand needed

awaiting sand

cold

sand not available

not in time

hot

sand not available

awaiting WB

get WB

barrier available

place barrier

final
Optional Extension of the Unfolding

- **Start**
  - Alert
  - Sand needed
    - Call sand
    - Call bags
  - awaiting sand
    - Not in time
    - Get sand
    - Get bags
  - Sand not available
  - Bags available
  - Fill bags
  - Barrier available
    - Place barrier
    - Final

- **Stop**
  - Sand needed
    - Call sand
    - Awaiting sand
    - Not in time
  - Sand not available
    - Nearby WB
      - Get WB
      - Barrier available
        - Place barrier
        - Final
Keep a Consistent View

start

alert

sand needed

bags needed

call sand

call bags

awaiting sand

awaiting bags

not in time

sand not available

sand not in time

not available

cold

sand needed

awaiting sand

not in time

not available

hot

availability

awaiting WB

get WB

barrier available

place barrier

final
Imperative Extension of the Unfolding

- Start
  - Alert
    - Sand needed
      - Call sand
        - Sand needed
          - Await sand
        - Call bags
          - Bags needed
            - Call sand
          - Await bags
            - Sand not available
              - Not in time
                - Await sand
              - Not in time
                - Sand not available
                  - Call WB
                    - Sand not available
                      - Await WB
                        - Get WB
                          - Barrier available
                            - Place barrier
                              - Final
                            - Final
                          - Get WB
                            - Barrier available
                              - Place barrier
                                - Final
                              - Final
**Anti-Scenario**

- **Start**
  - Call sand
  - Call bags

- **Sand needed**
  - Call sand
  - Call bags

- **Awaiting sand**
  - Not in time
  - Get bags

- **Sand not available**
  - Call WB

- **Awaiting WB**
  - Get WB

- **Barrier available**
  - Place barrier

- **Final**

### Anti

- **Awaiting bags**
  - Get bags

- **Bags available**
  - Call bags

- **Call WB**
**Anti-Scenario Cancels Behavior**

- **Start**
  - **Alert**
    - **Sand Needed**
      - **Call Sand**
      - **Call Bags**
    - **Bags Needed**
      - **Call Bags**
  - **Awaiting Sand**
  - **Awaiting Bags**
  - **Sand Not Available**
    - **Call WB**
  - **Awaiting WB**
    - **Get WB**
      - **Barrier Available**
        - **Place Barrier**
        - **Final**

- **Anti**
  - **Awaiting Bags**
    - **Get Bags**
    - **Bags Available**
    - **Call WB**
Process Adaptation in The Big Picture

Unfolding (N) \[\rightarrow\] \[\text{oclet}_1(N) \ldots \text{oclet}_n(N)\] \[\rightarrow\] Unfolding (N’)

**fire brigade**
- sand needed
- awaiting sand
- sand available

**gravel pit**
- sand called
- sand available
- truck available
- delivering

*cold scenario - optional*
Process Adaptation in The Big Picture

Unfolding(N) \[ \rightarrow \] \[ \rightarrow \] Unfolding(N')

oclet_1(N) \[ \ldots \] oclet_n(N)

scenario_1 \[ \ldots \] scenario_k

oclet_1(M) \[ \ldots \] oclet_m(M)

Unfolding(M) \[ \rightarrow \] \[ \rightarrow \] Unfolding(M')
Process Adaptation in the Big Picture

Unfolding(N) \[\rightarrow\] oclet\(_1\)(N) \[\rightarrow\] \ldots \[\rightarrow\] oclet\(_n\)(N) \[\rightarrow\] Unfolding(N’)

Unfolding(M) \[\rightarrow\] oclet\(_1\)(M) \[\rightarrow\] \ldots \[\rightarrow\] oclet\(_m\)(M) \[\rightarrow\] Unfolding(M’)

Net N \[\rightarrow\] \ldots \[\rightarrow\] Net M

specification S

behavior space of S

views on S

Net N’ \[\rightarrow\] \ldots \[\rightarrow\] Net M’
Issues & Future Work

- formal definition of adaptation operation
- consistency of a specification S
- computing views of S without Unfolding(N)
- consistency of distributed adaptations
- properties of the behavior space
  - soundness
  - controllability
  - adaptivity wrt. a certain change in the environment
  - self-stabilizing
- feasibility study/case study
- proof-of-concept implementation
Adaptive Processes in Disaster Management

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(?)!!!.ThankYou