

DCR Graphs for Adaptable Security of Industrial Strength

Thomas T. Hildebrandt

joint work with

S. Debois (ITU), T. Slaats (KU), R. Mukkamala (CBS), M. Marquard (Exformatics), D. Basin (ETH Zurich)



IT University of Copenhagen (ITU) Denmark

January 10th, 2017

based on ForMABS 2016 keynote @ ASE2016

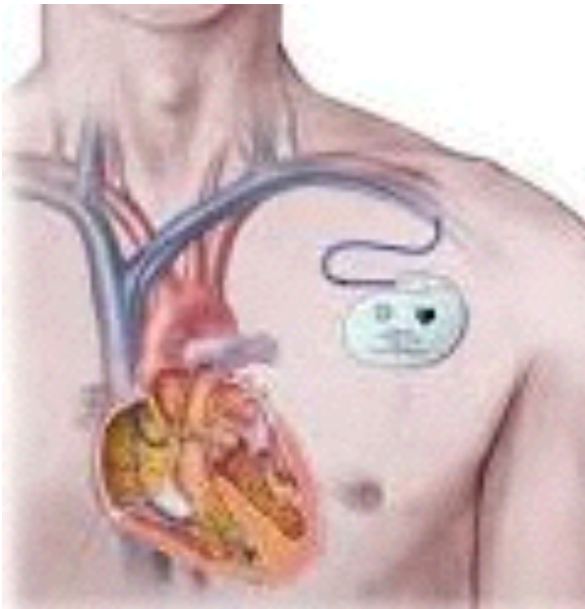


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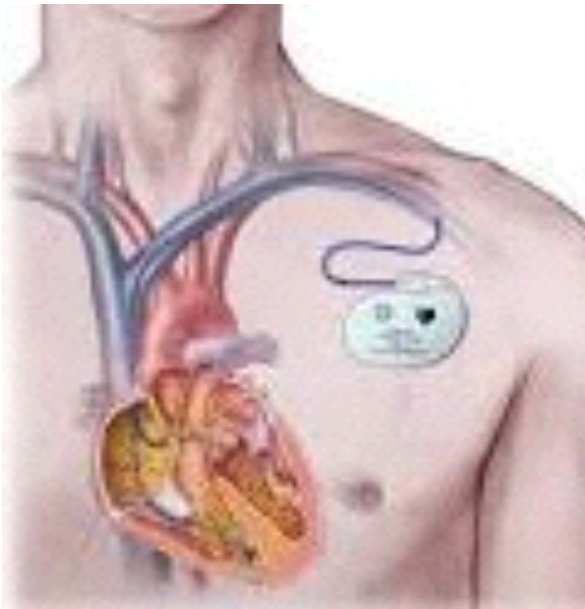
IT systems increasingly control and support critical processes & interactions between humans and machines



from embedded systems to knowledge workflows, gathering & using personal data and continuously being updated.....



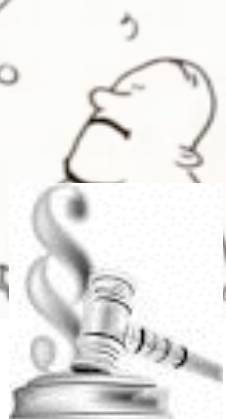
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Correctness & compliance with legal, safety and security regulations is getting more and more critical!



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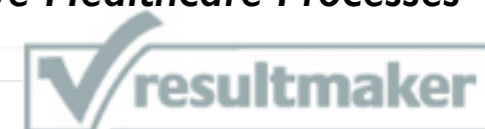
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Declarative process modelling

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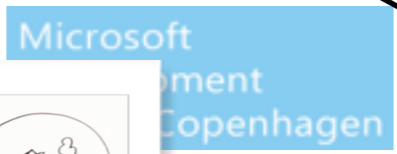
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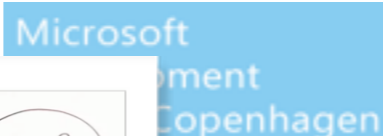
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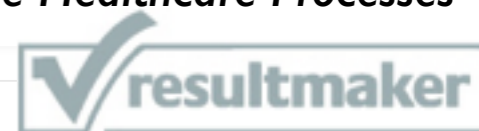
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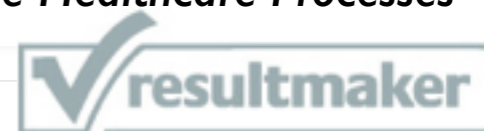
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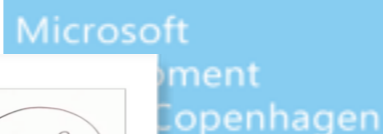
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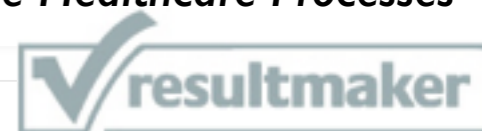
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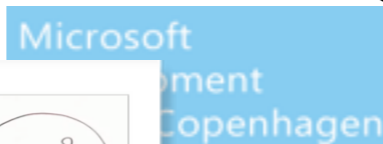
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2015-16: *ProSec: Cyber security and ICT Infrastructure with importance to crucial functions in Denmark - Mapping Emergency and Security Processes in the Danish Public Transport Sector and their Dependency on ICT* (Royal Danish Defence College)

Key points of this talk

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- **Correctness and security:** Need for formalisation of processes & data-flow involving both humans and IT

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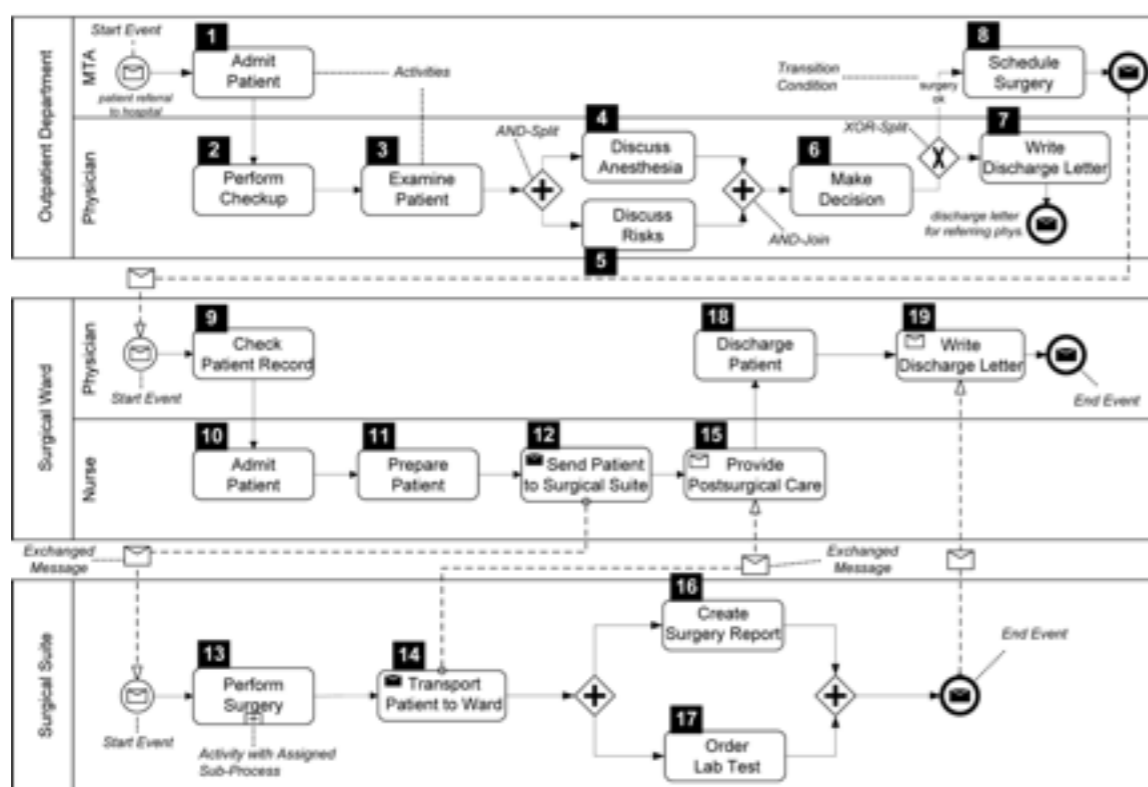
- **Correctness and security:** Need for formalisation of processes & data-flow involving both humans and IT
- **Effectiveness, maintainability & compliance:** Need for “intelligent”, flexible & adaptable IT systems

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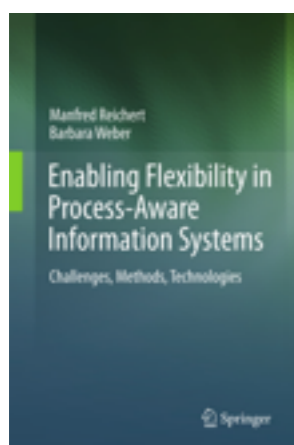
- **Correctness and security:** Need for formalisation of processes & data-flow involving both humans and IT
- **Effectiveness, maintainability & compliance:** Need for “intelligent”, flexible & adaptable IT systems
- **The Dynamic Condition Response (DCR) Graphs** process technology is a promising approach developed jointly by industry and academia and supported by tools DCRGraphs.net & dcr.itu.dk

Classical Business Process

based on *enactable* process flow diagrams (e.g. BPMN)

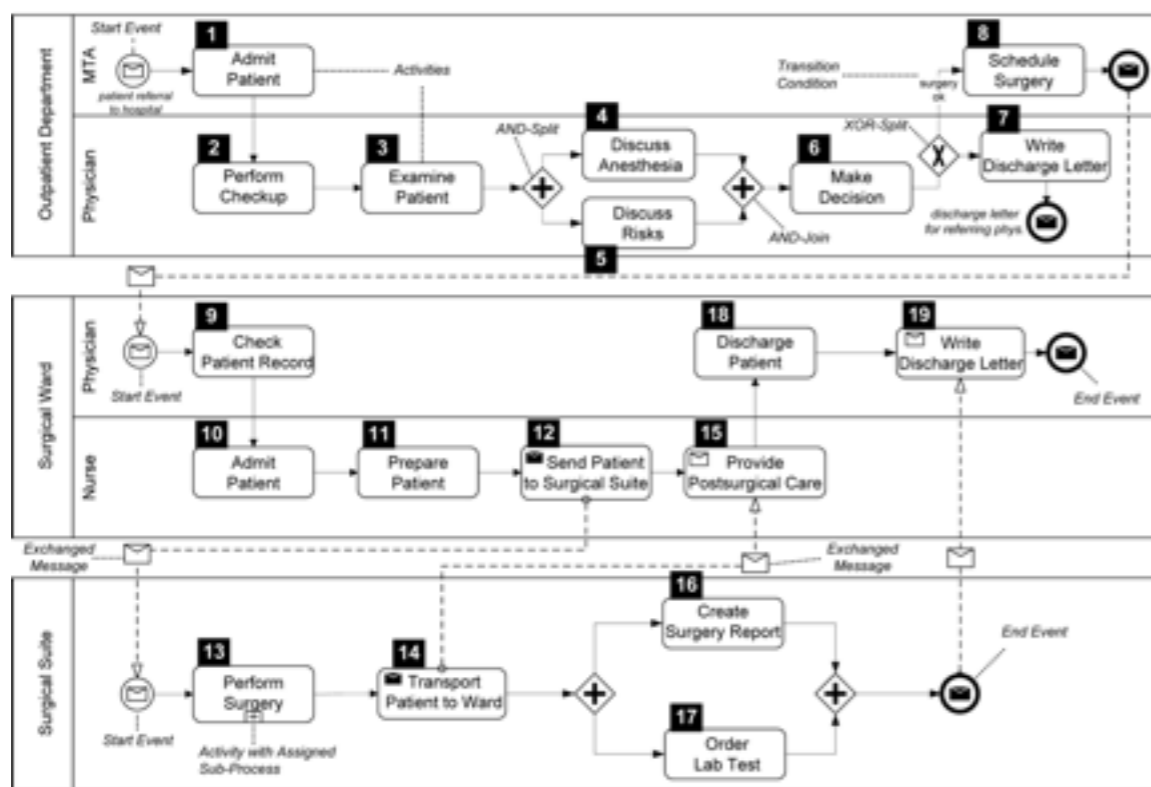


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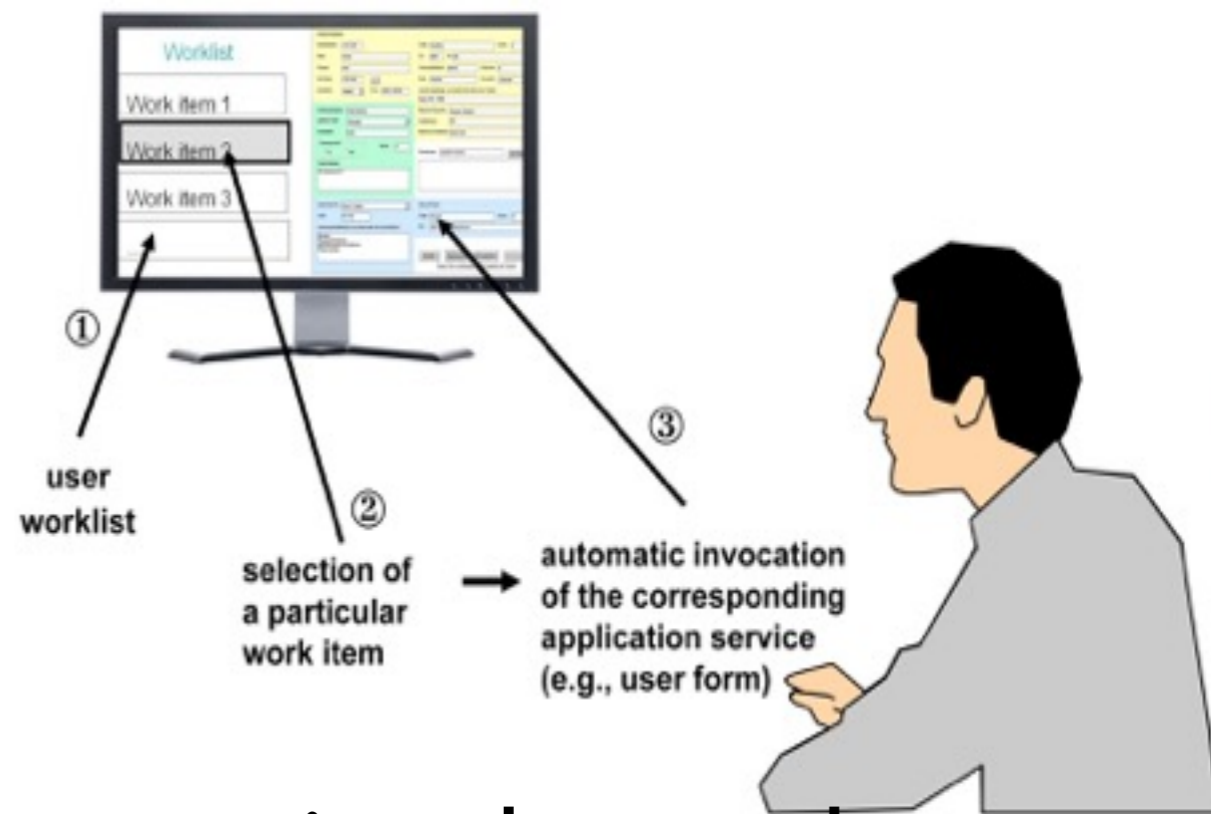


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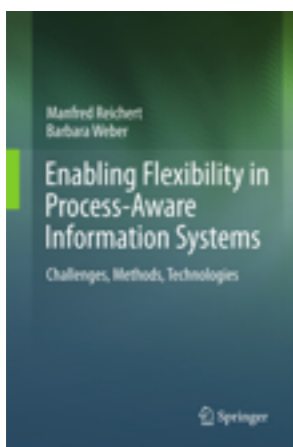


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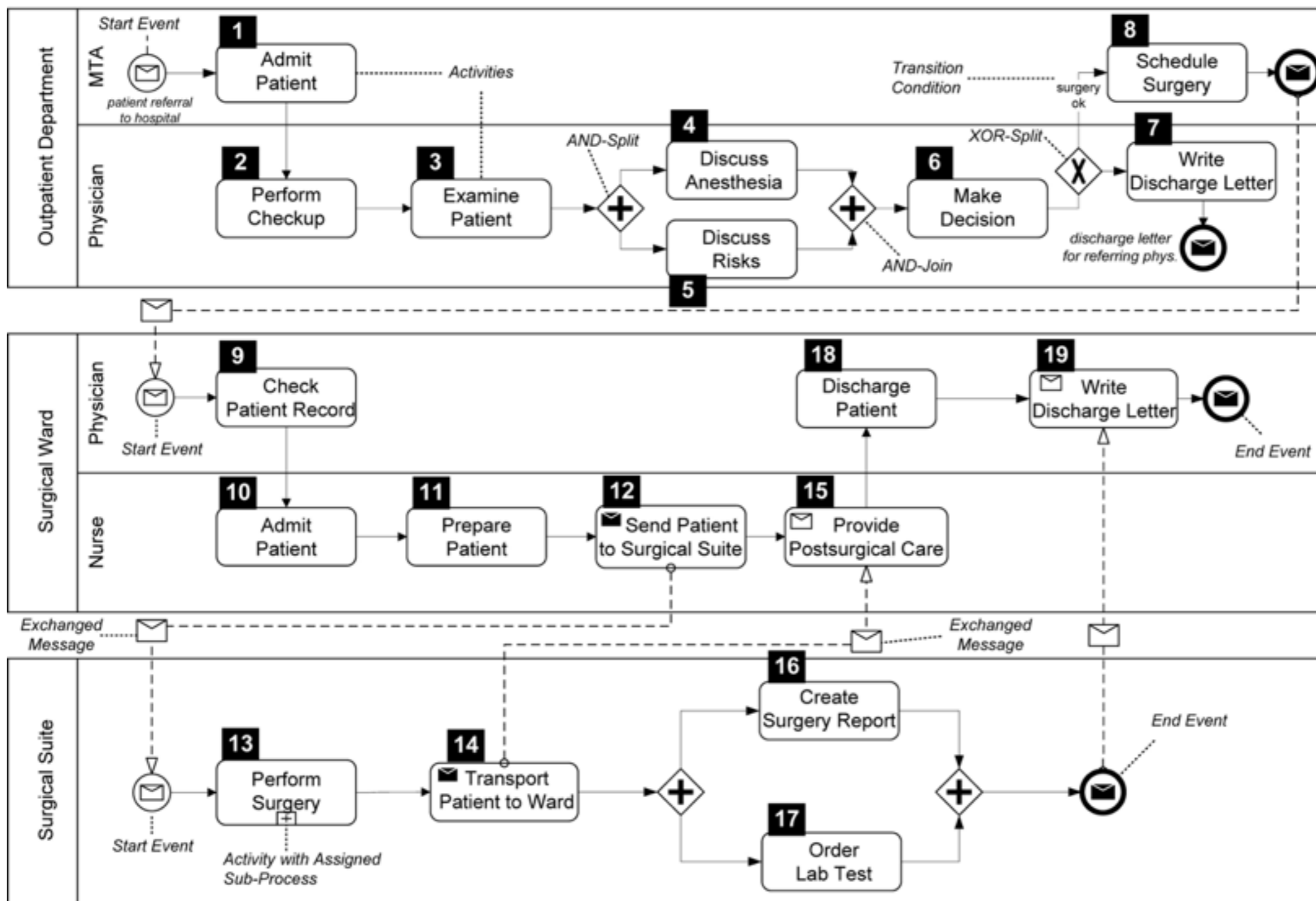


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supporting the worker
& (partially) automating workflows



What is the problem with flows?

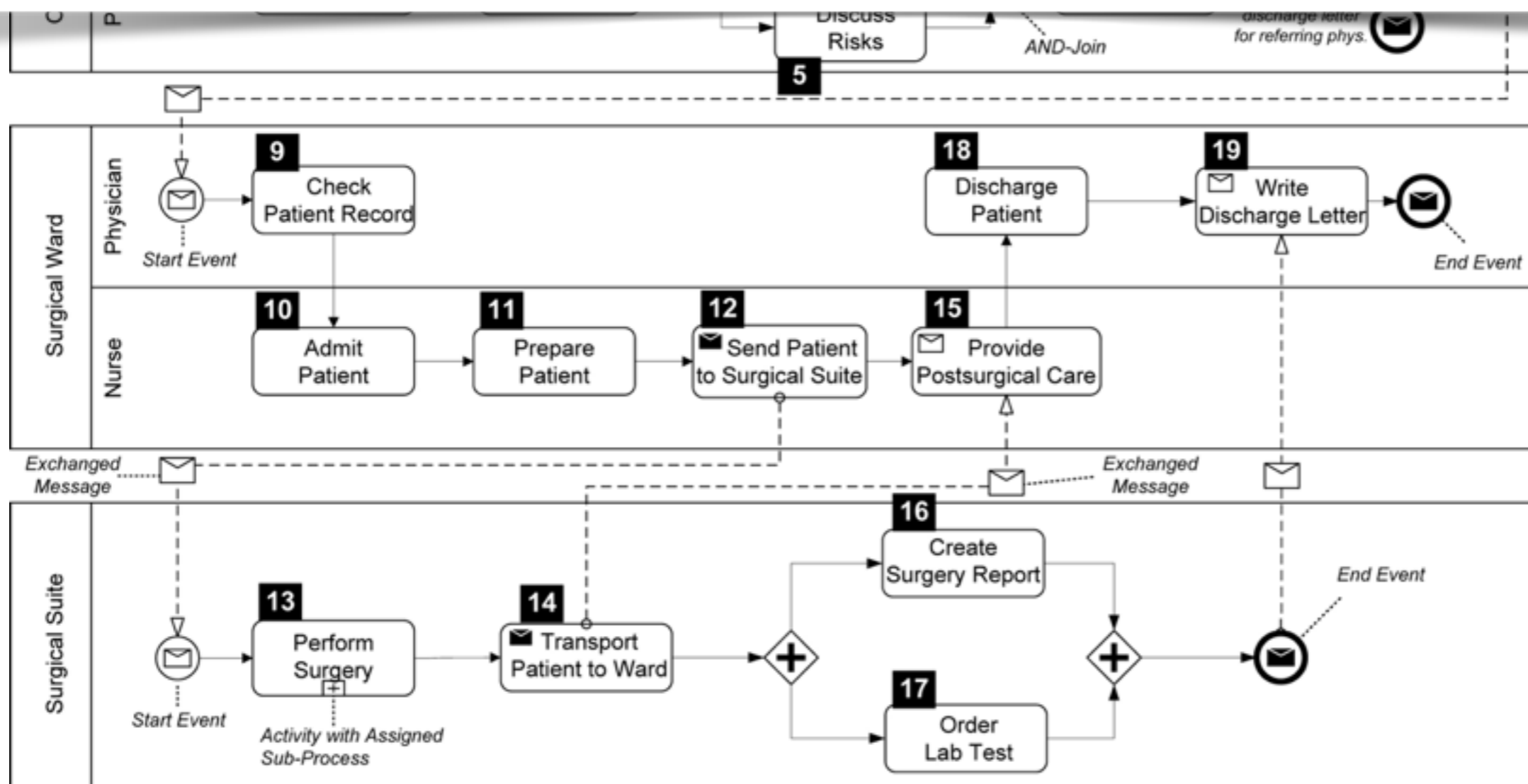


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What is the problem with flows?

Too rigid development and execution

Difficult to adapt & describe only anticipated paths!

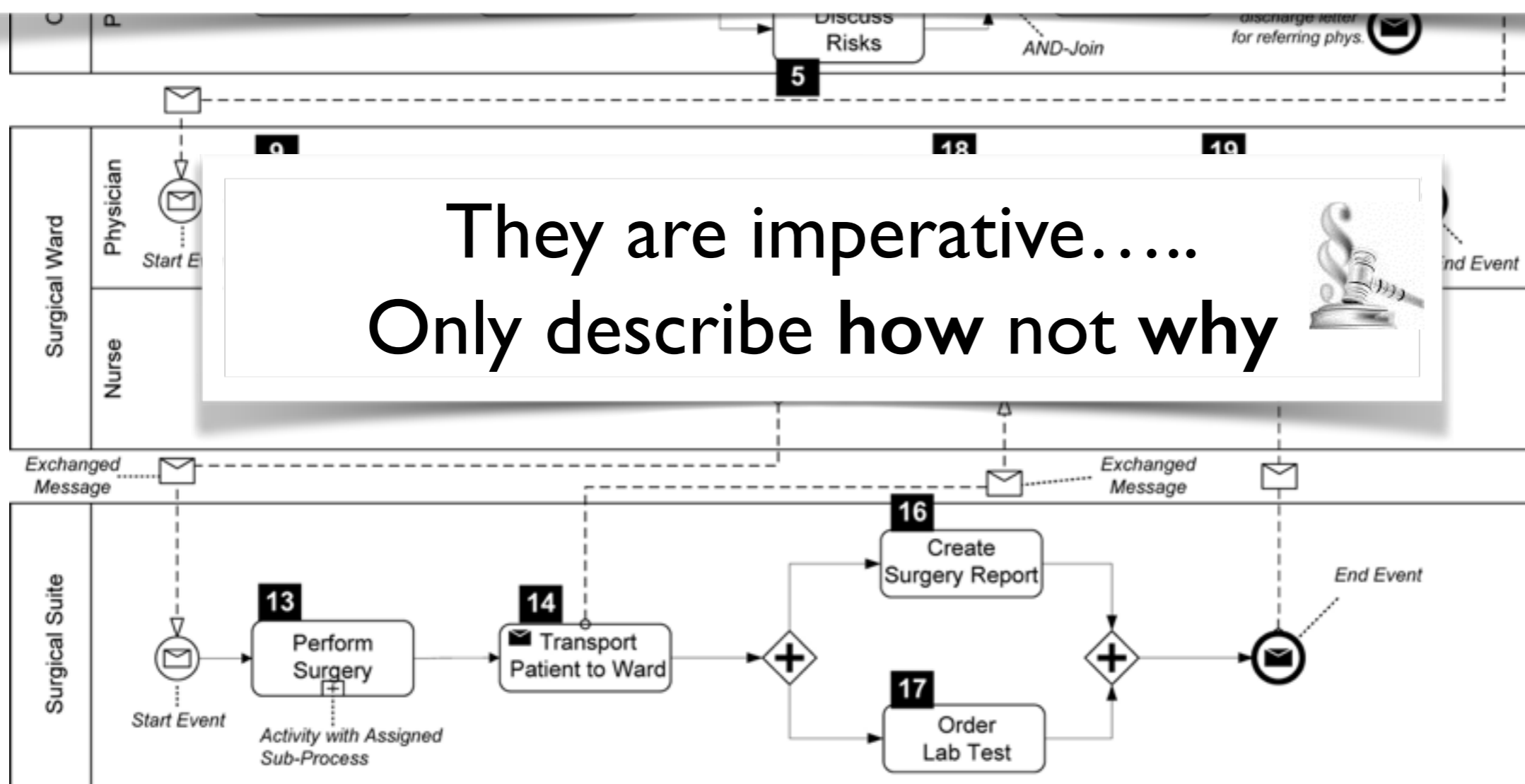


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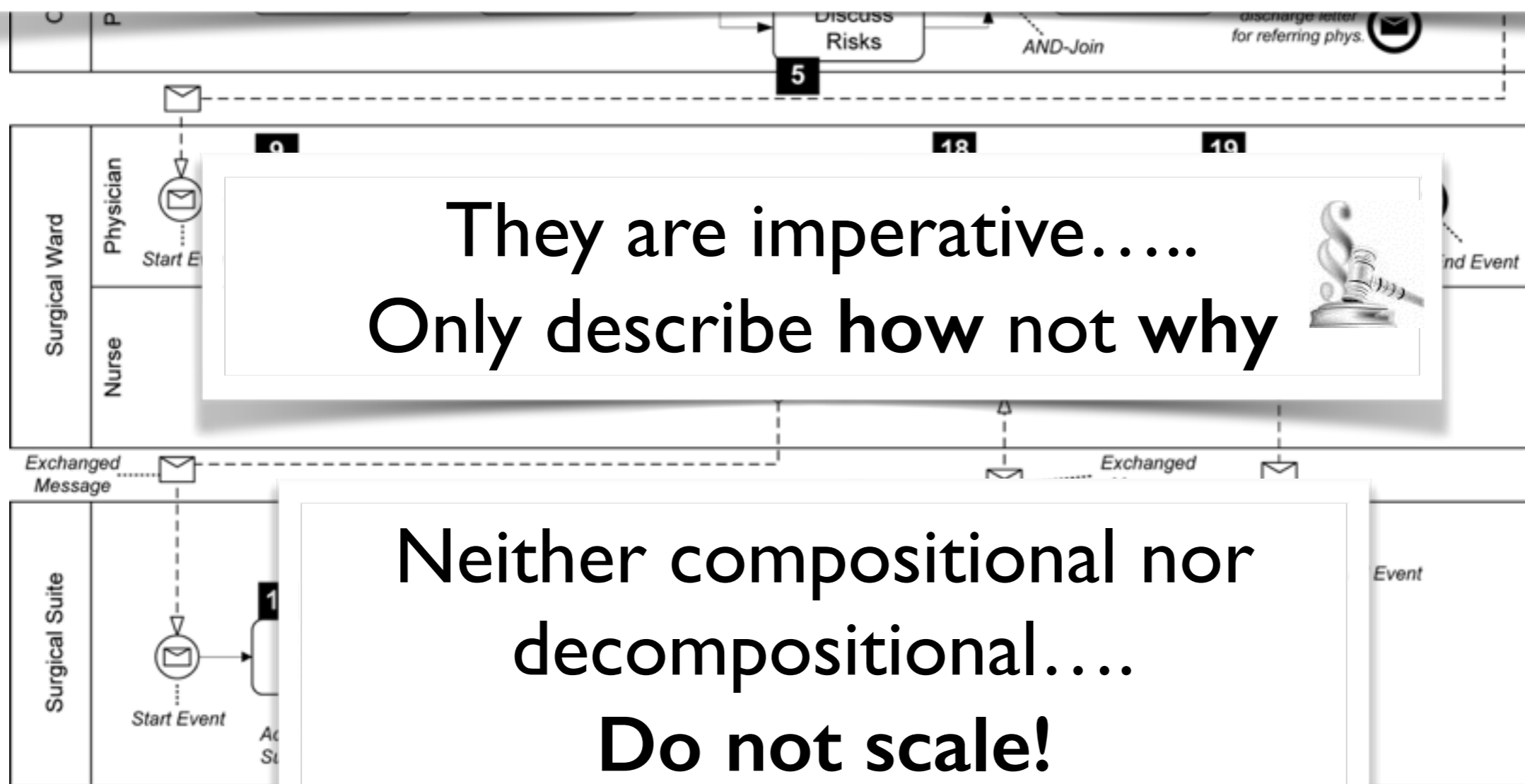


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They are imperative.....
Only describe how not why

Neither compositional nor
decompositional.....
Do not scale!

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Like driving in the dark...



Like driving in the dark...

with printed fixed route(s)



Like driving in the dark...

with printed fixed route(s)

If you leave the route,
you are on your own &
can not see the road



Like driving in the dark...

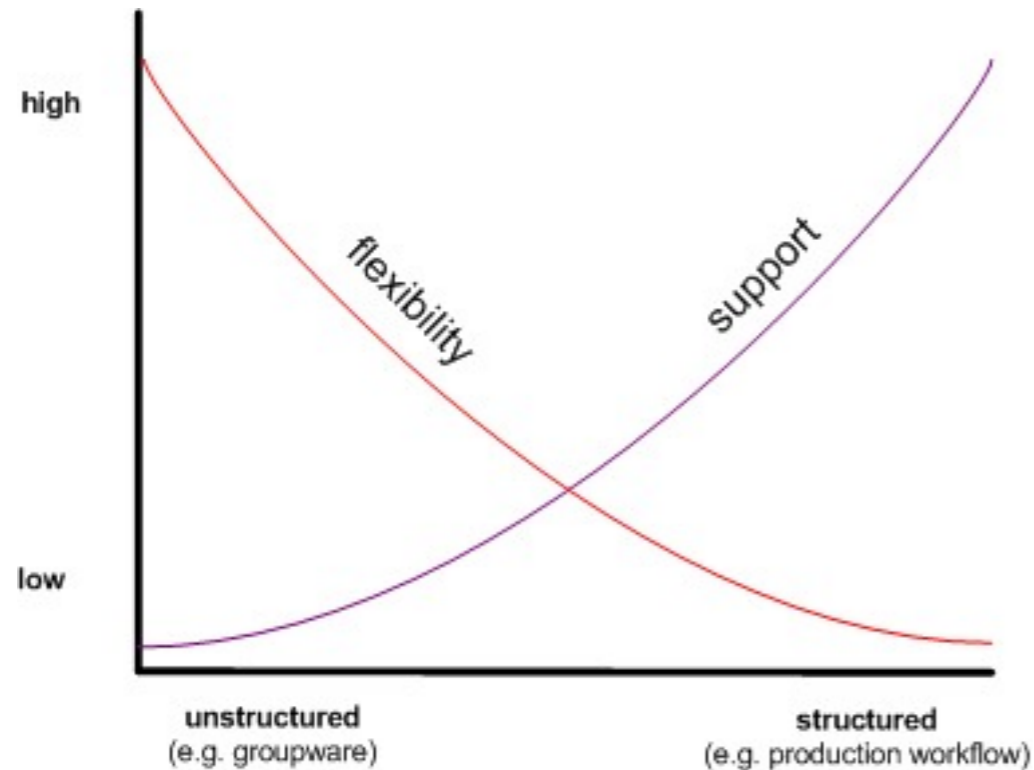
with printed fixed route(s)

If you leave the route,
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If the map changes,
you have no idea how to
update the routes



Flexibility versus Support



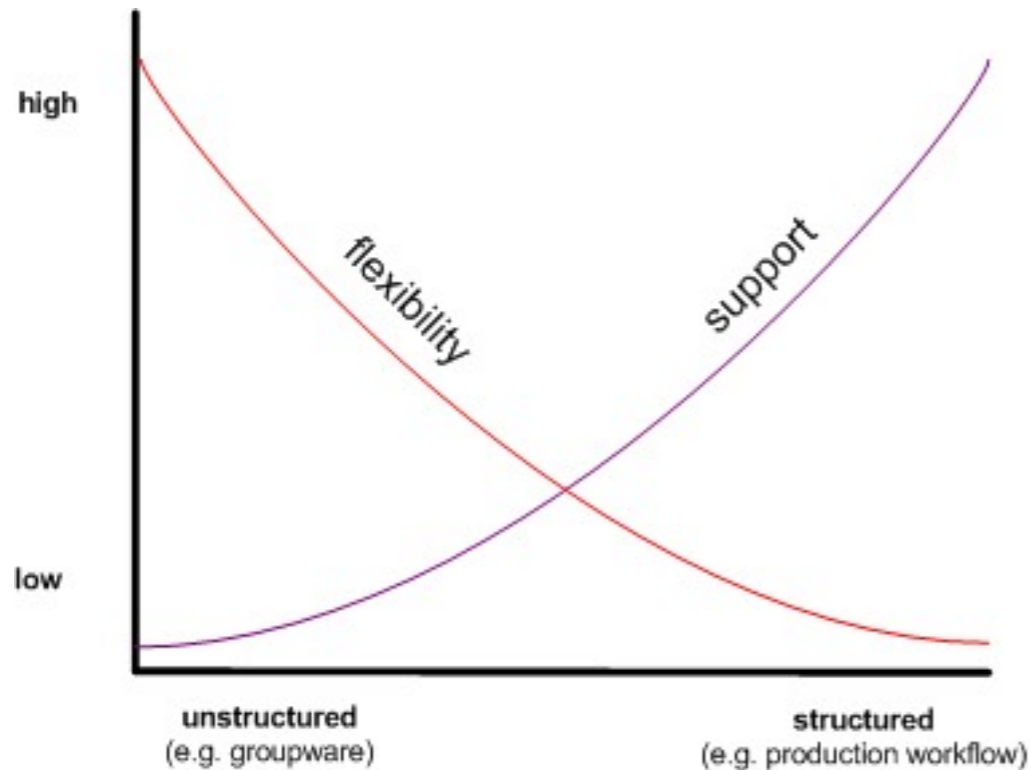
Classical trade-off between flexibility and support!

Already in 1983, researchers in Computer Supported Cooperative Work (CSCW) concluded that office automation systems “do not deal well with unanticipated conditions” (Barber) & “were automating a fiction” (Sheil)

[Schmidt & Bannon: Taking CSCW Seriously: Supporting Articulation Work, 1992]

[1] W.M.P. van der Aalst et al. Declarative workflows: Balancing between flexibility and support

Flexibility versus Support



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“Good standards for business process modelling are still missing and even today’s WFMSs are too rigid”

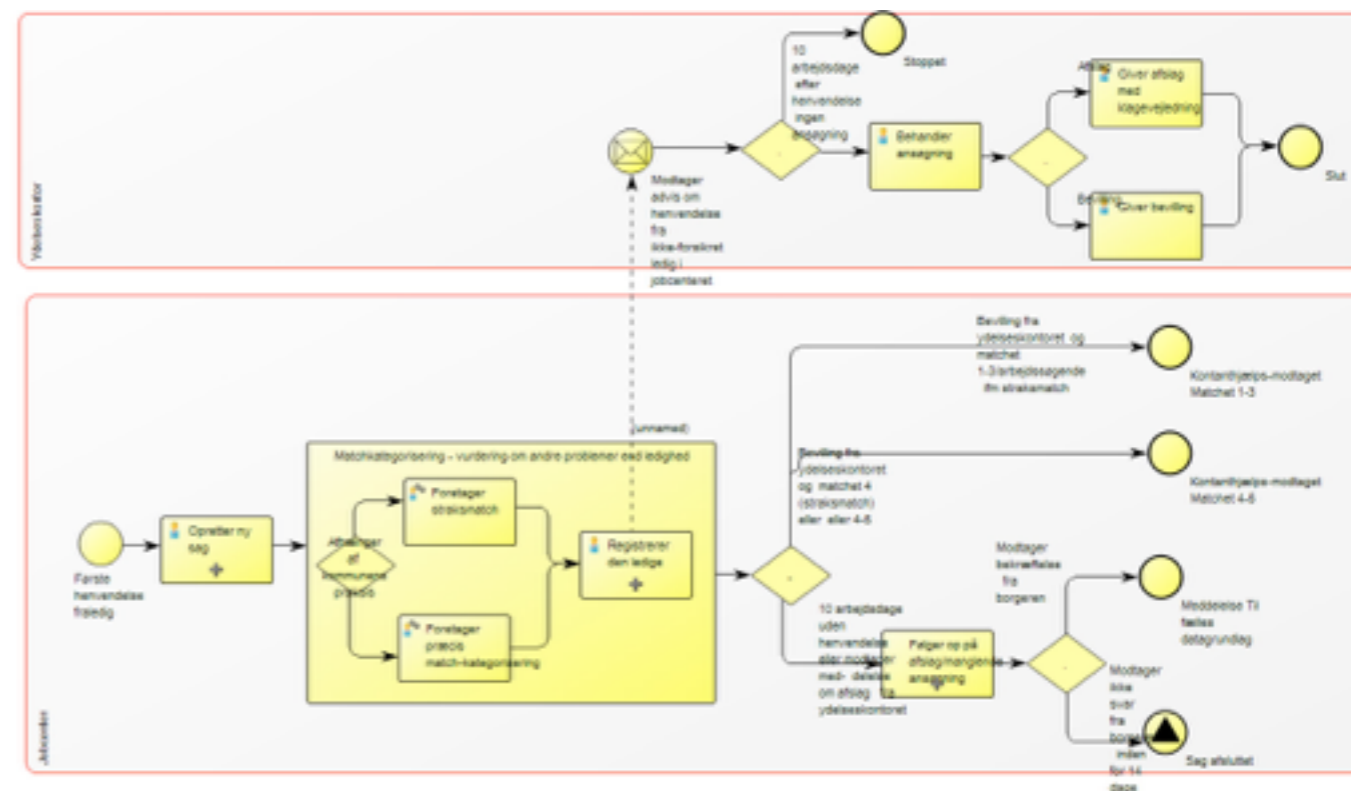
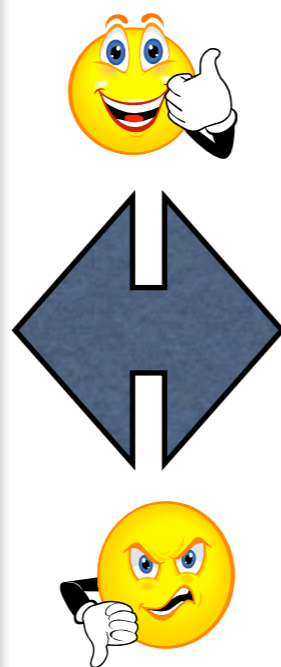
Process-Aware Information Systems:
Design, Enactment, and Analysis

Wil M.P. van der Aalst

Example from local government

Compliant?

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- Lov om Aktiv socialpolitik (LBK nr 946 af 01/10/2009)
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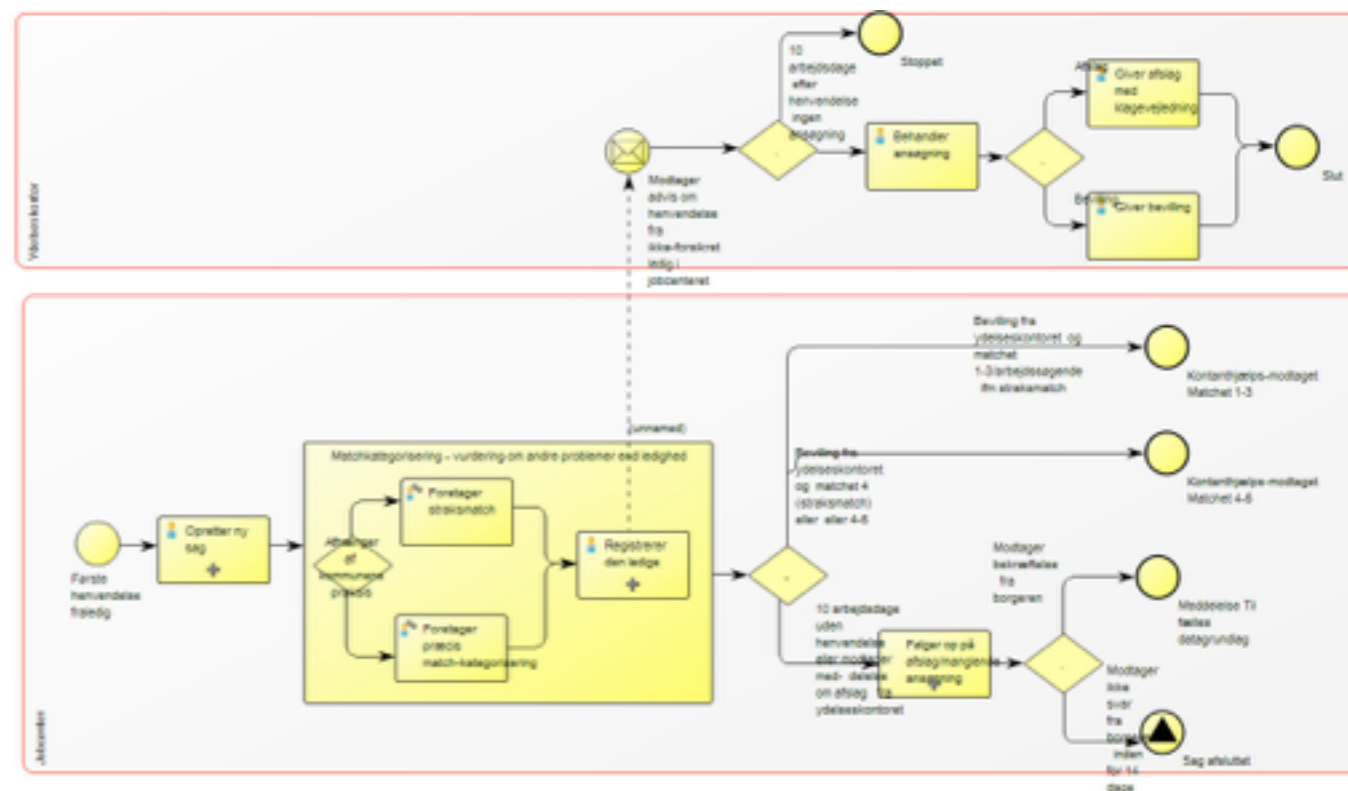
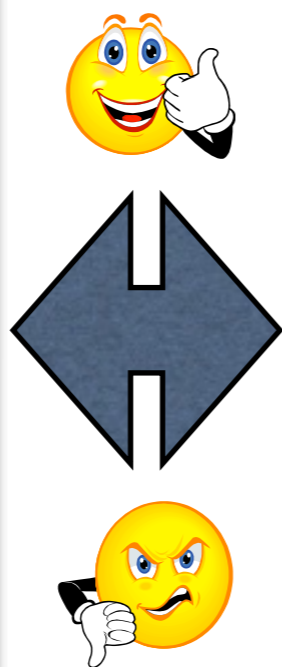
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Example from local government

Change in law Compliant?

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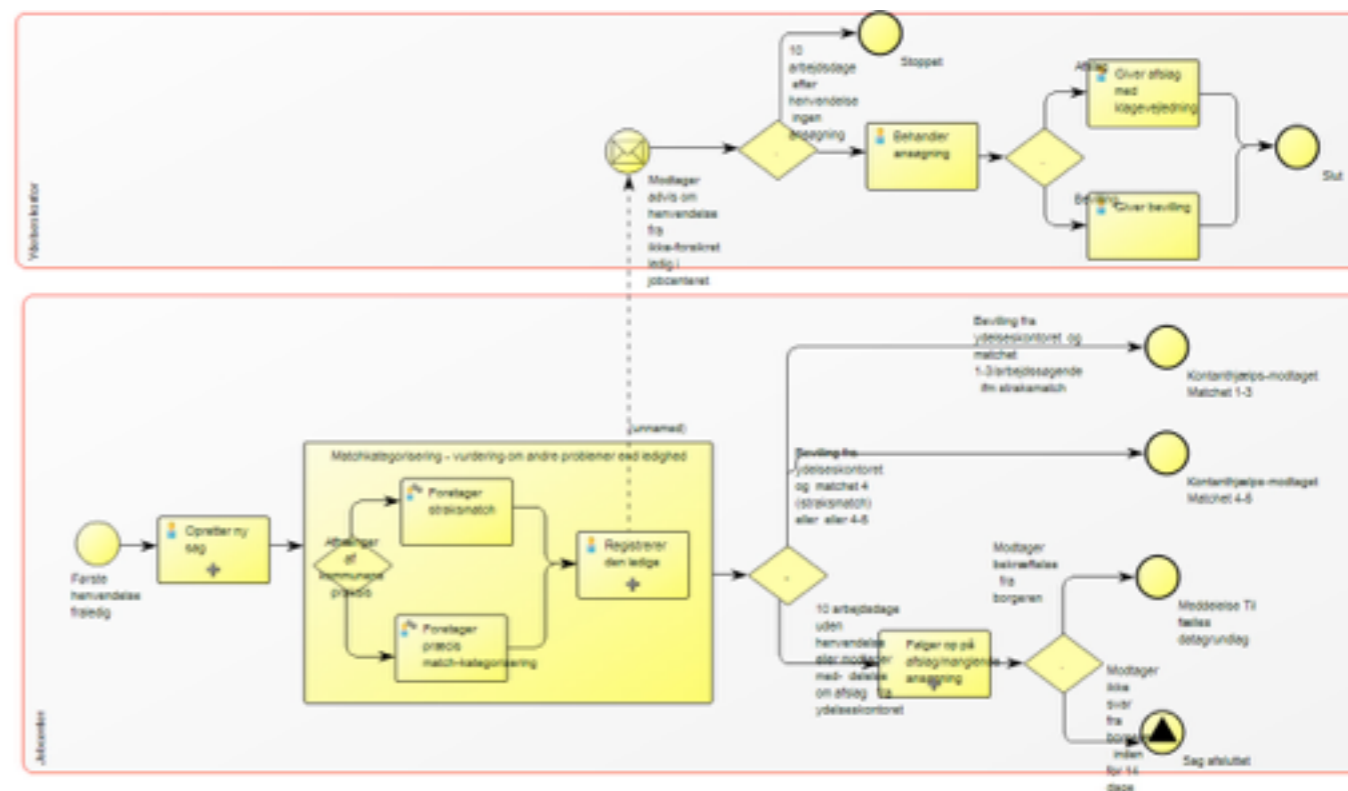
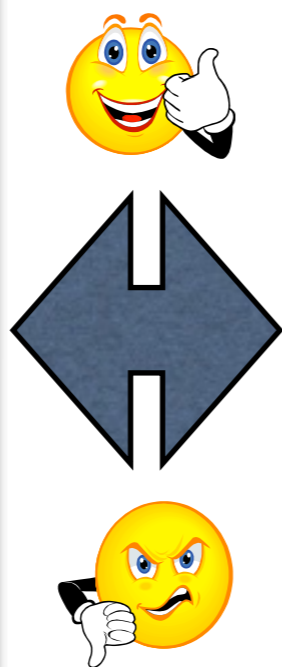
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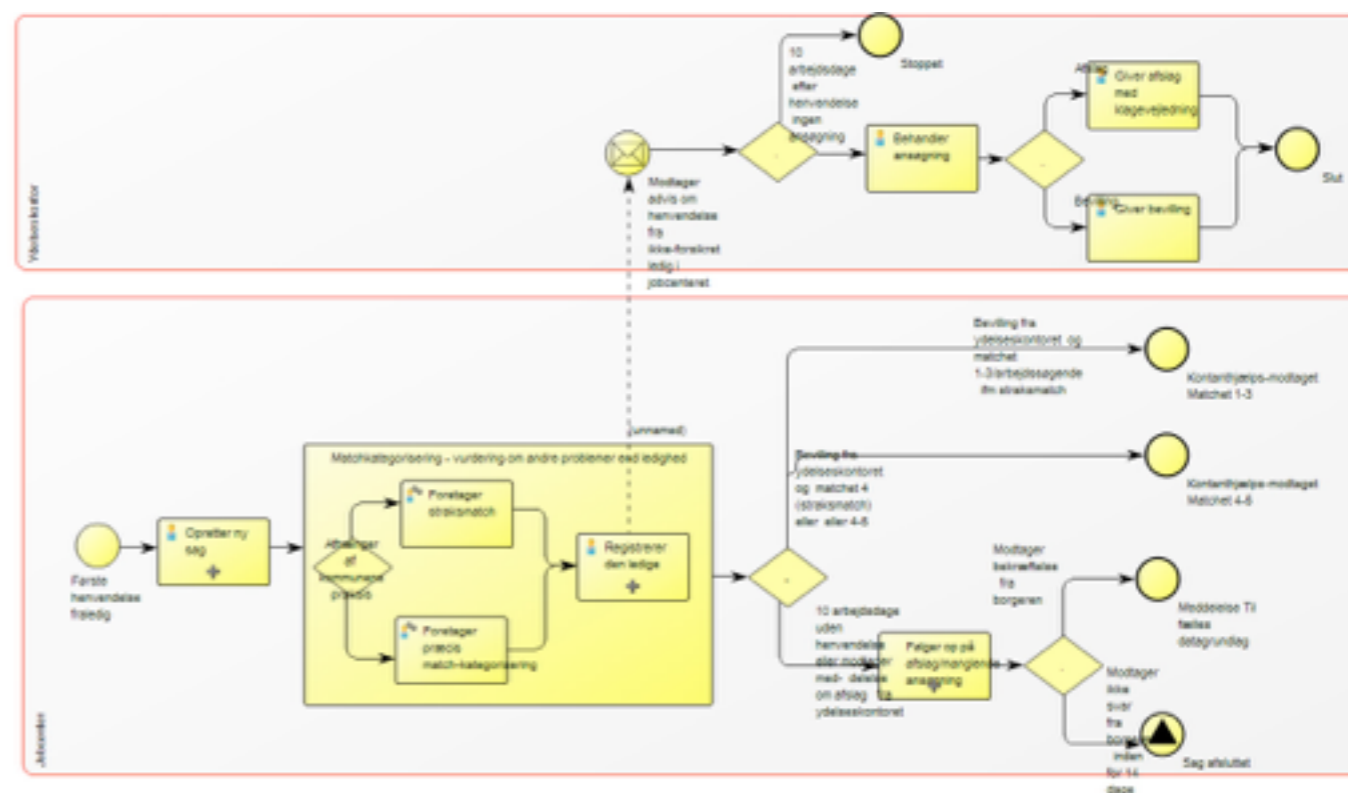
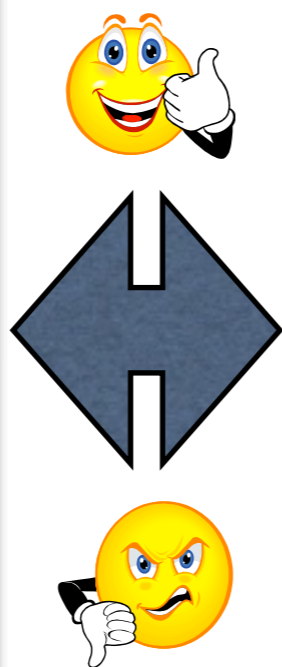
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Change in practice

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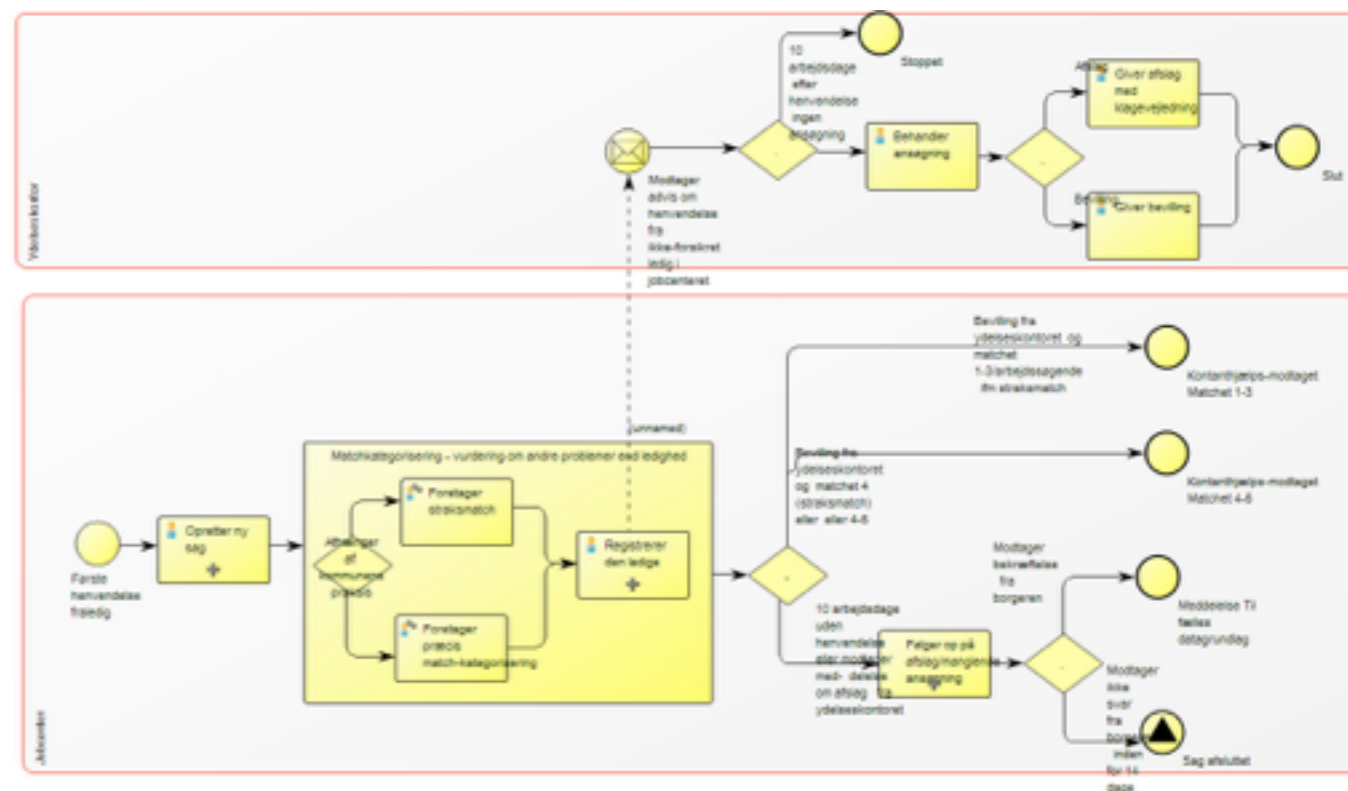
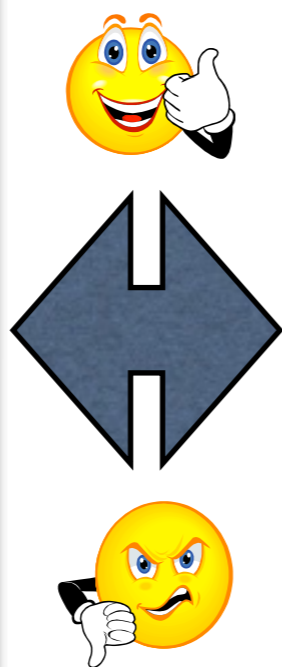
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Change in practice

Still compliant ??

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We need a workflow GPS



We need a workflow GPS

where the route is calculated from the map and your goal



We need a workflow GPS

where the route is calculated from the map and your goal

If you leave the route, a new one can be calculated



We need a workflow GPS

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If the map changes, the route can be adjusted



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this can be achieved with declarative process technology

Not a new idea

already in the '70ties we had declarative approaches

- Expert systems
- Logical programming (e.g. prolog)
- Temporal logic specifications

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Difficult for users to understand the notations
- and how the the suggested route was derived...

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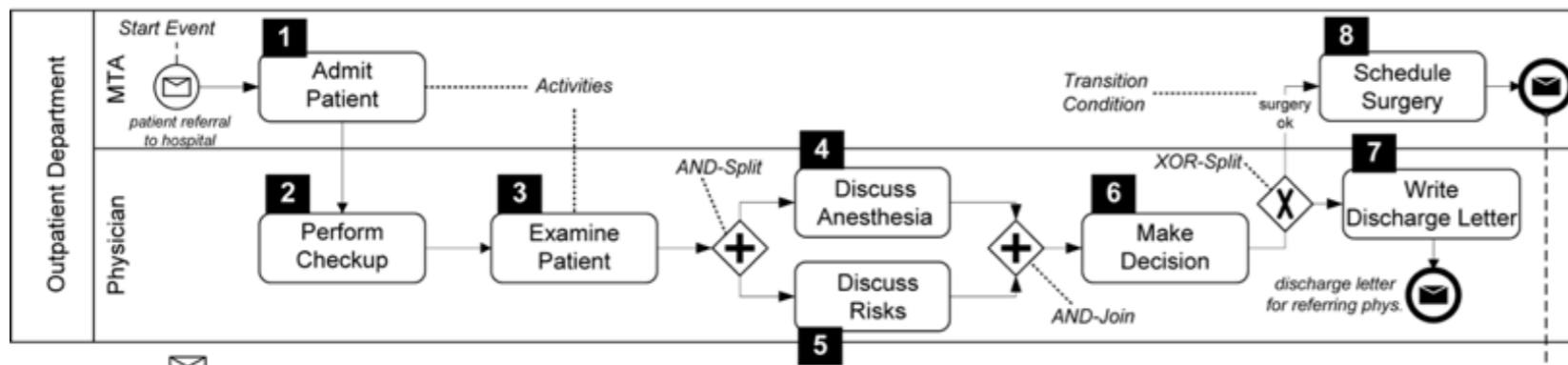
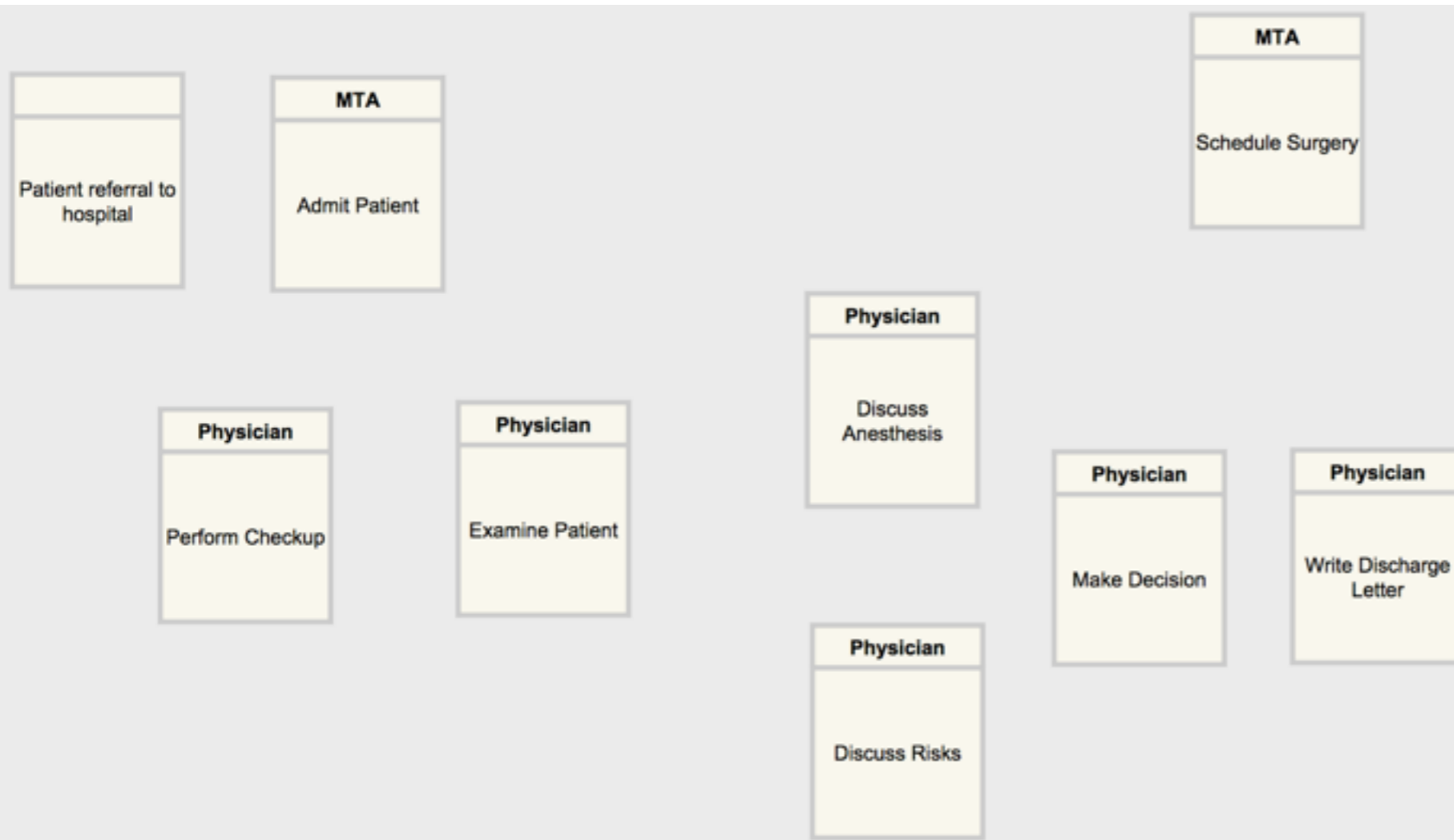
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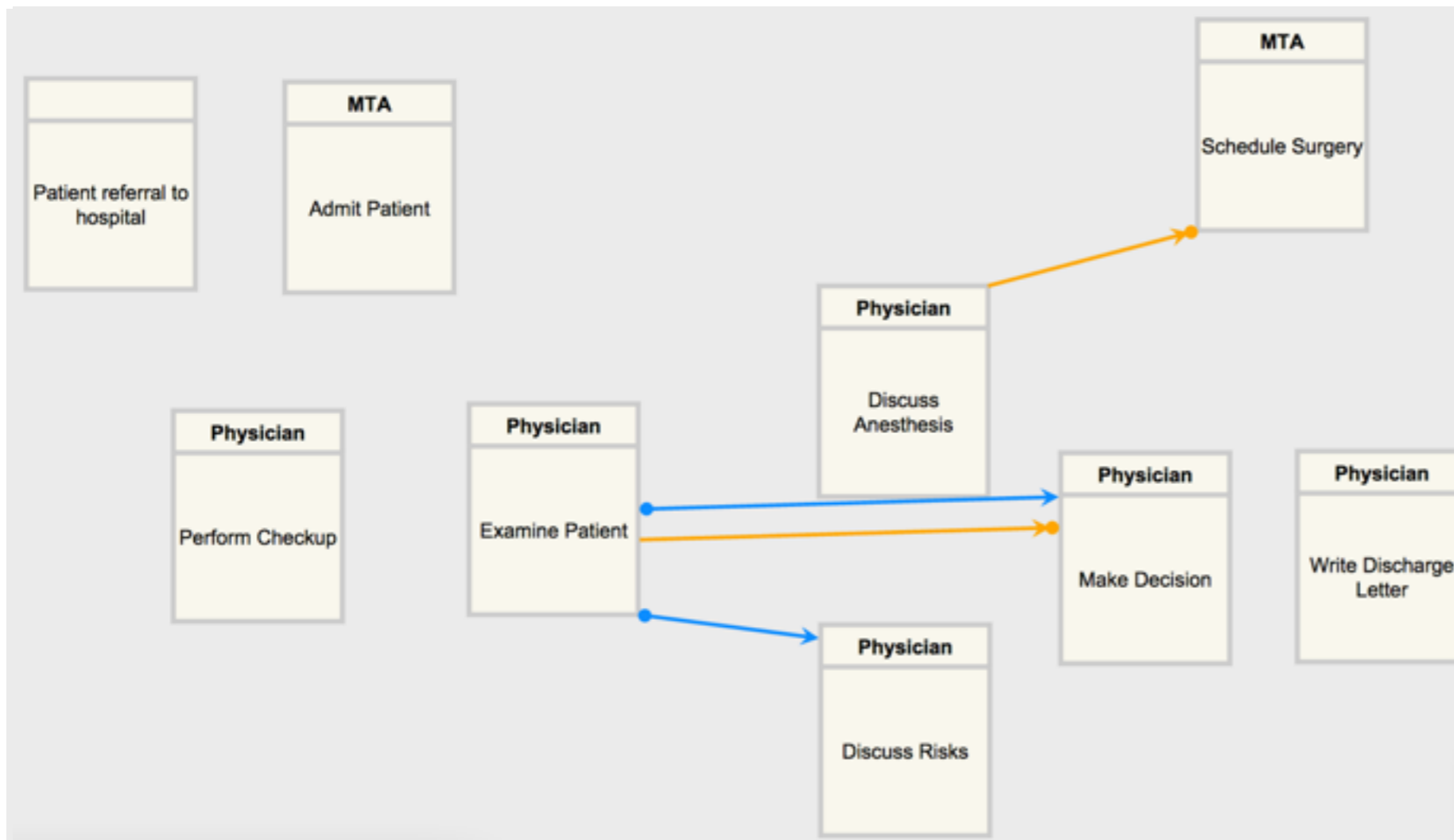
Dynamic Condition Response Graphs is a fresh attempt...

Dynamic Condition Response (DCR) Graphs

Events & roles



Constraints



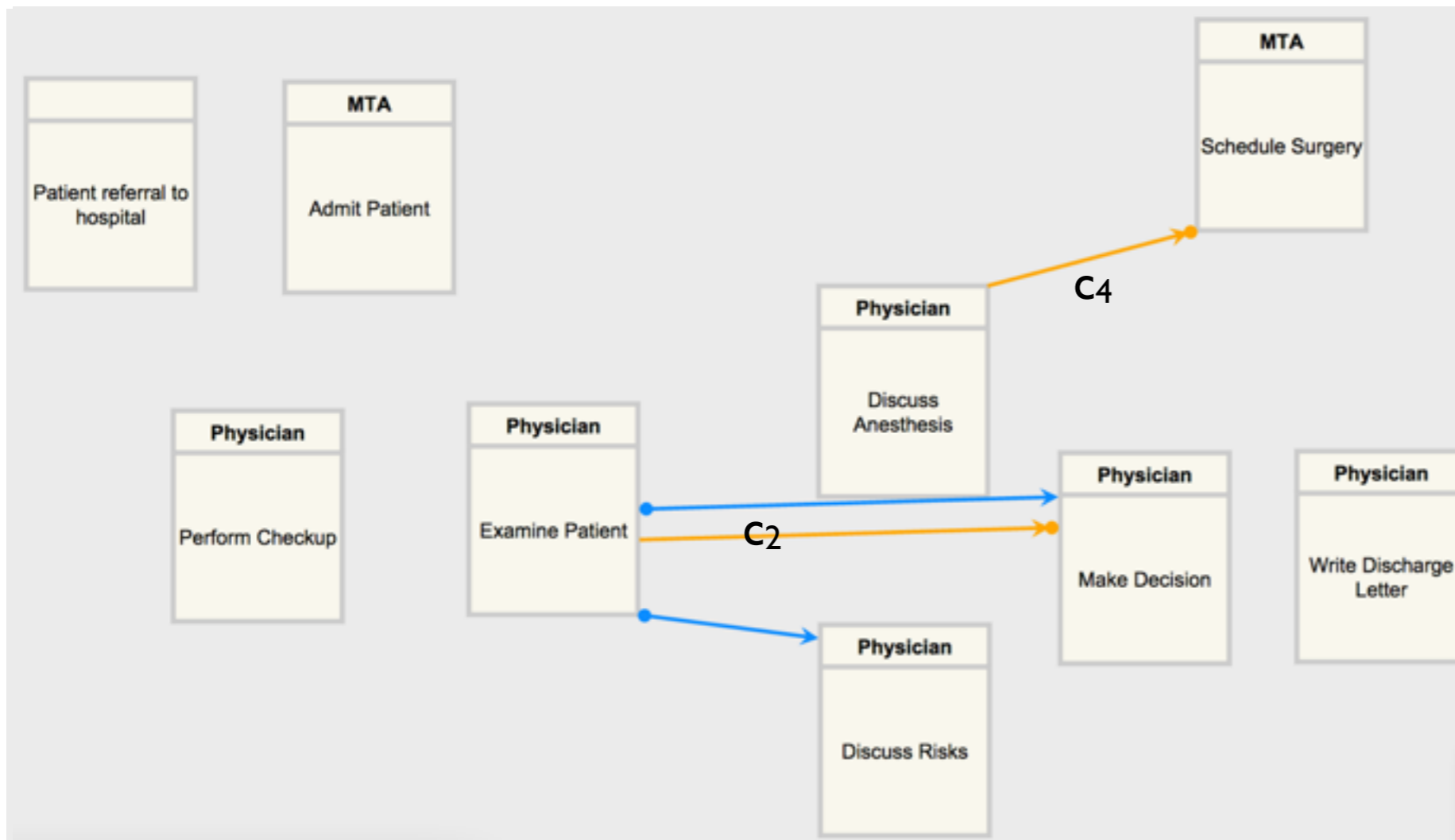
c_2 After examining the patient a decision must be made. However, this must not be done before the examination.

c_3 After the examination, the patient must be informed about the risks of the (planned) surgery.

c_4 Before scheduling the surgery the patient has to be informed about anesthesia.



Conditions



Conditions describe what must have happened in the past before an event *may* happen

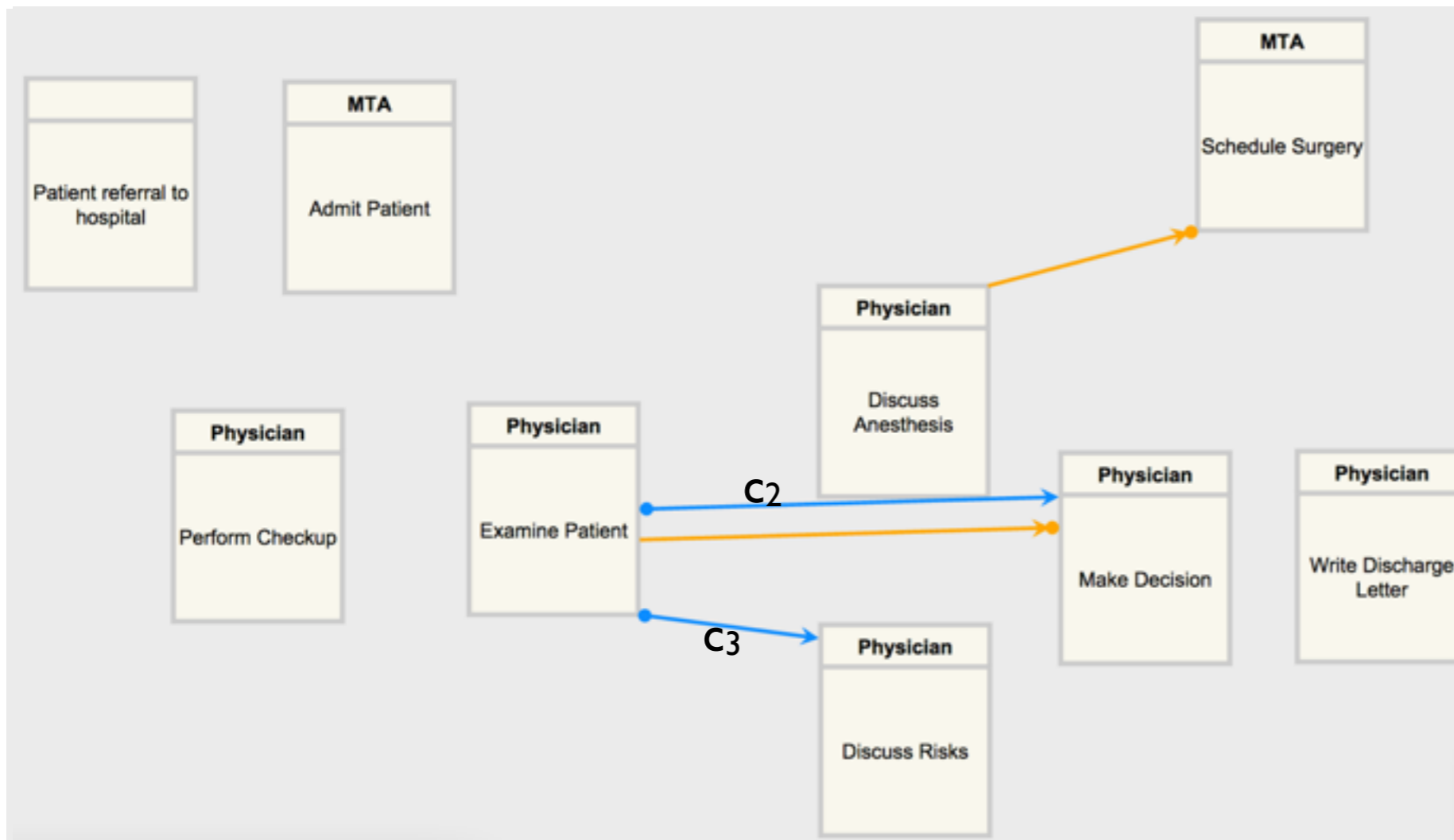
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Responses



Responses
describe what
must happen in
the future if an
event happens

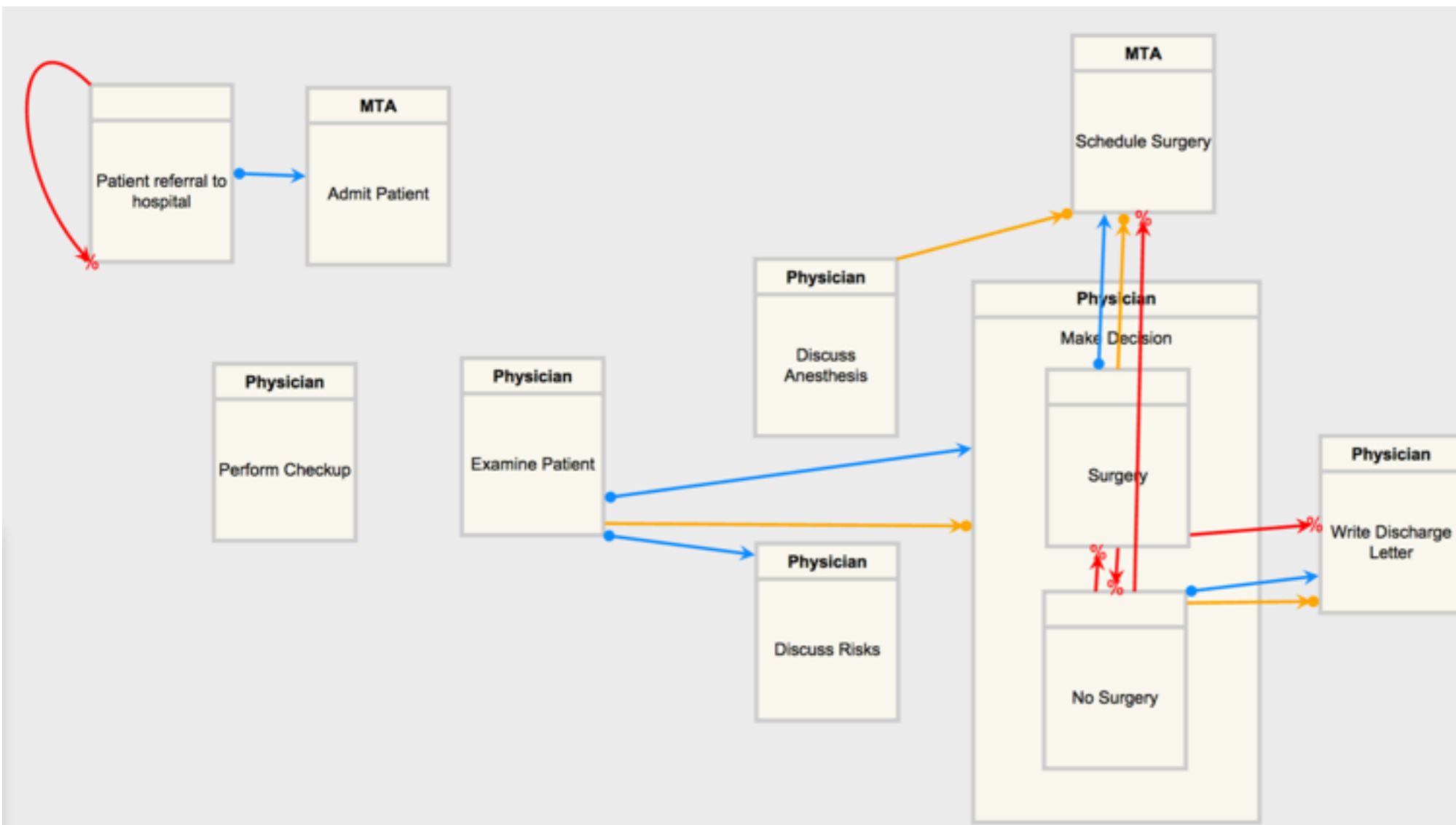
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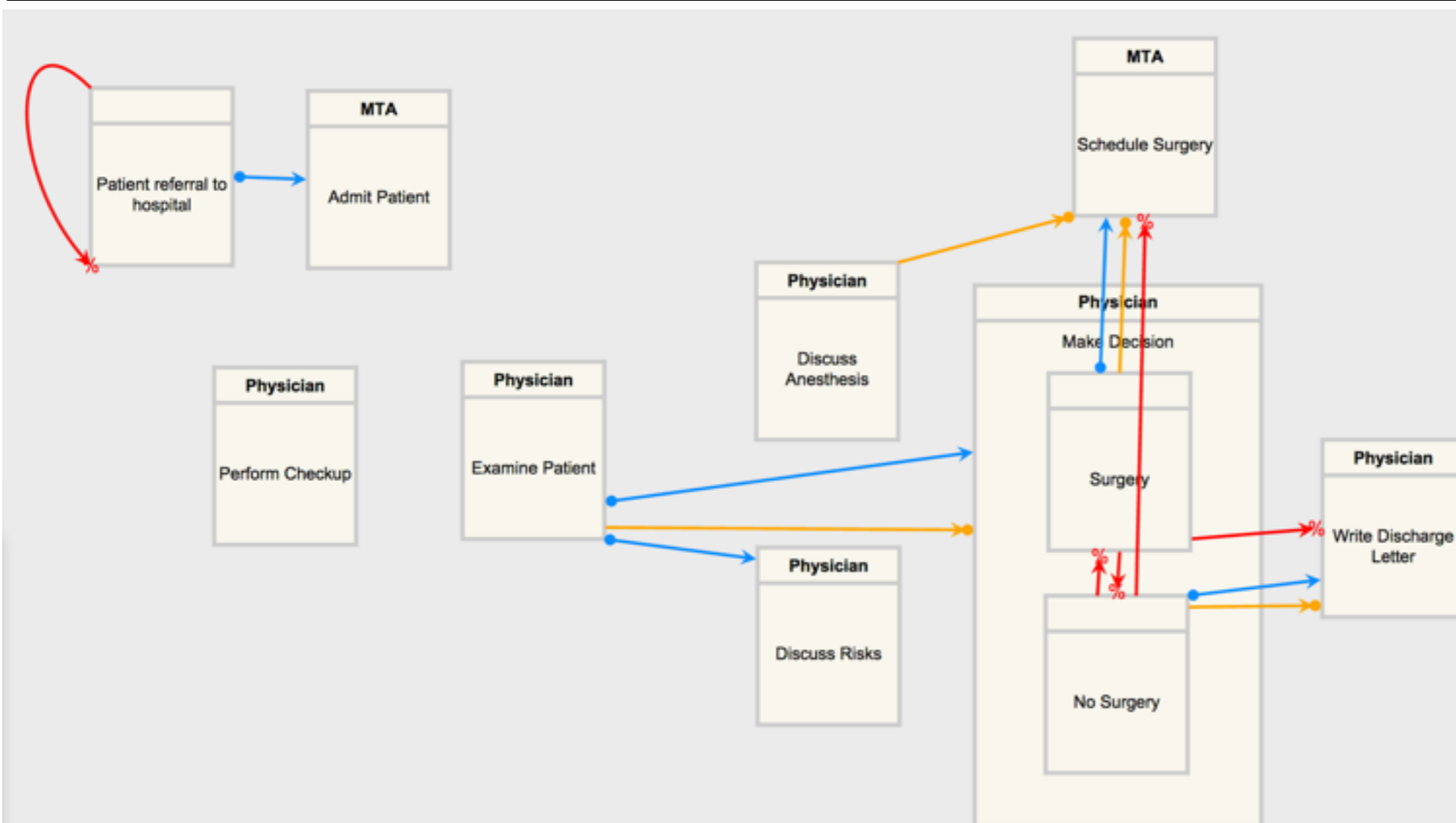


Exclusions

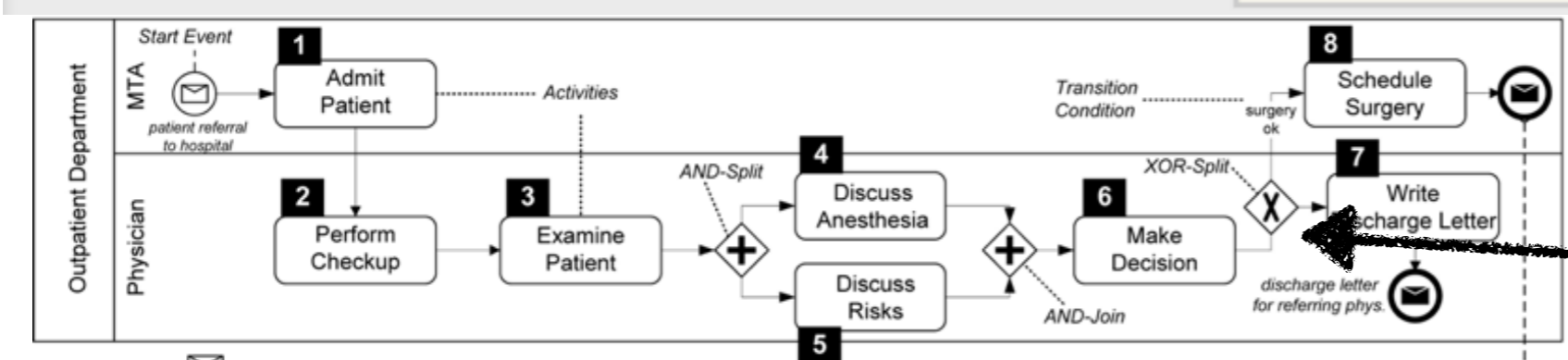


Exclusions describe that an event is no longer part of the process

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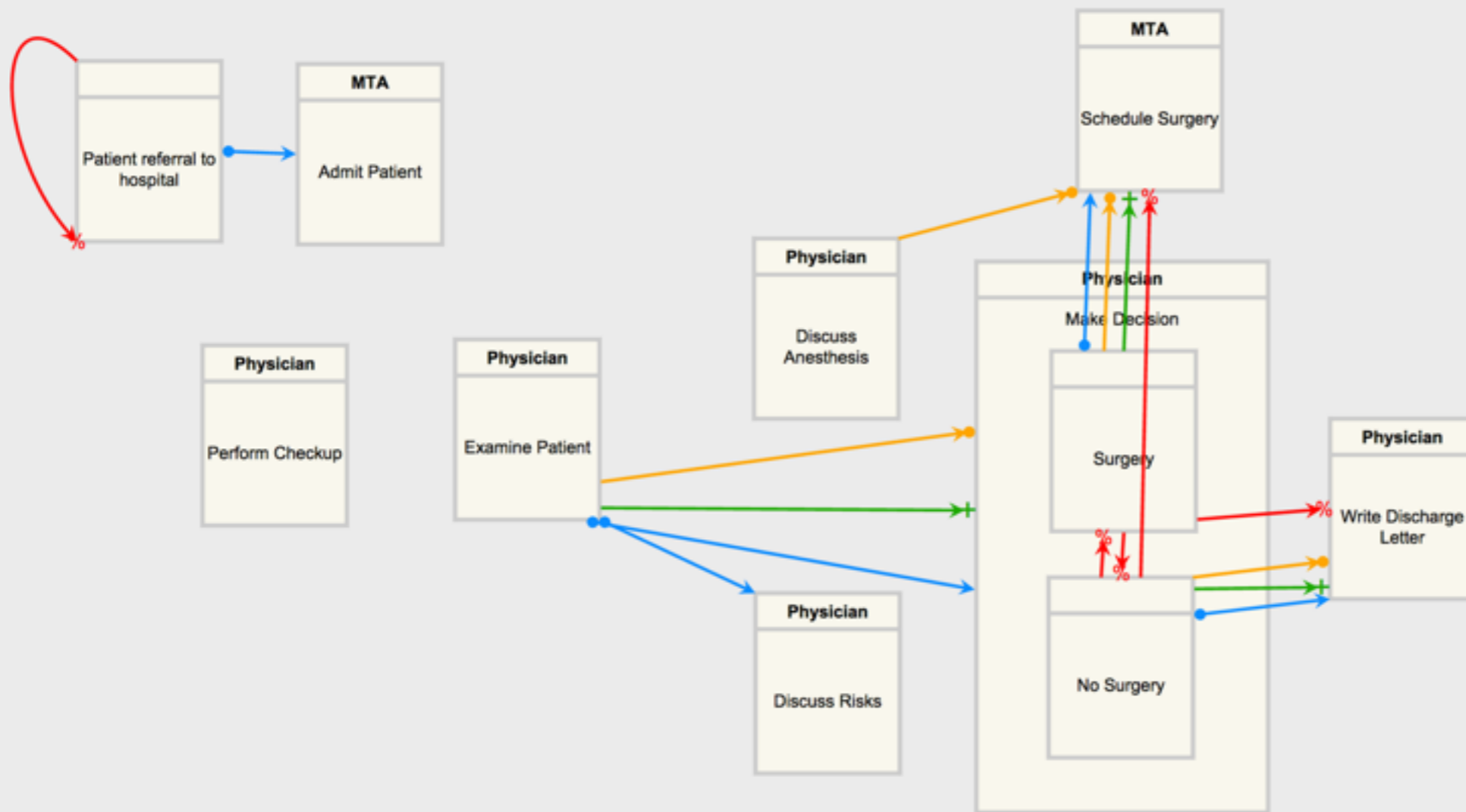


Exclusions describe that an event is no longer part of the process



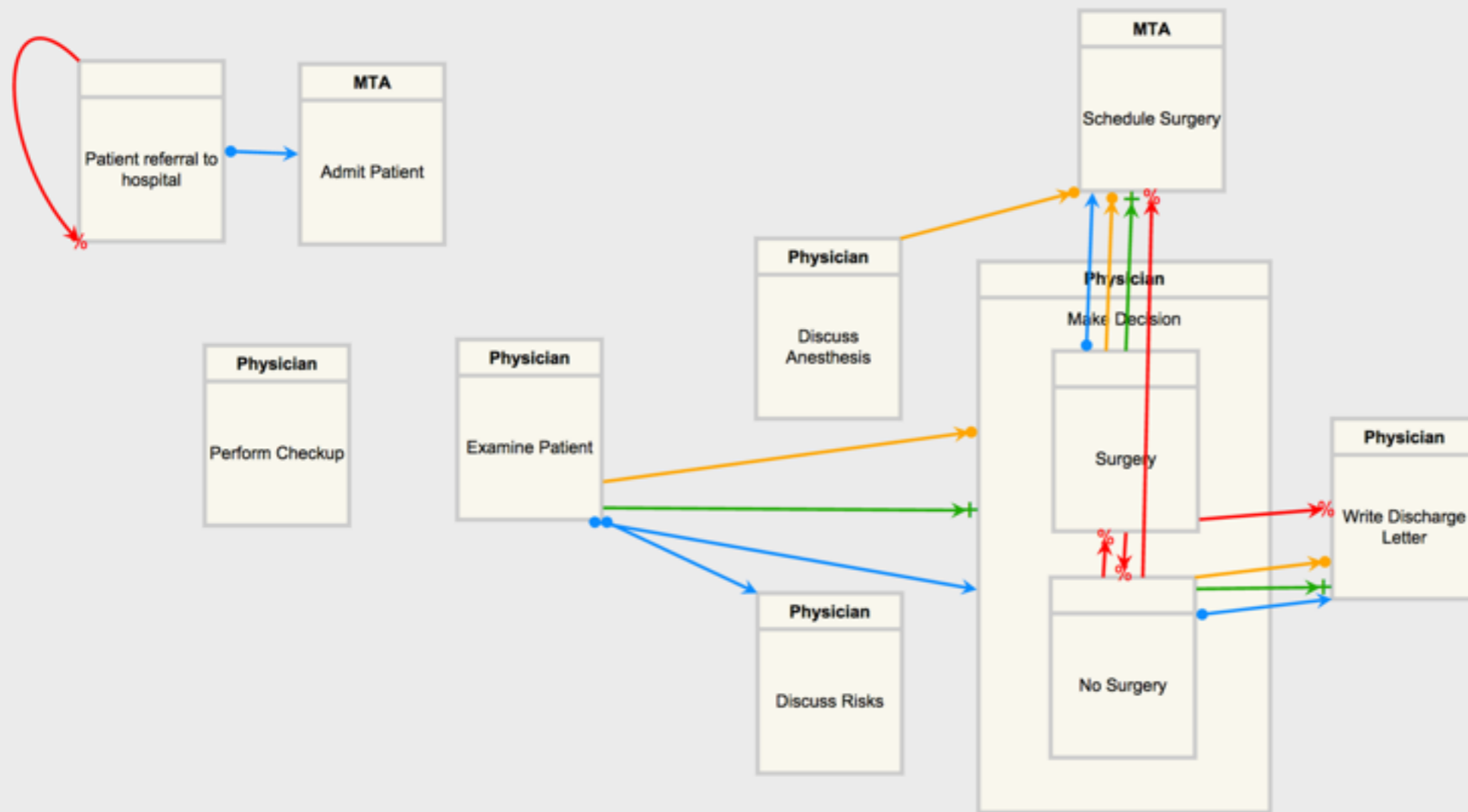
correspond to choices/branches

Inclusions



Inclusions describe that an event is again part of the process

Inclusions

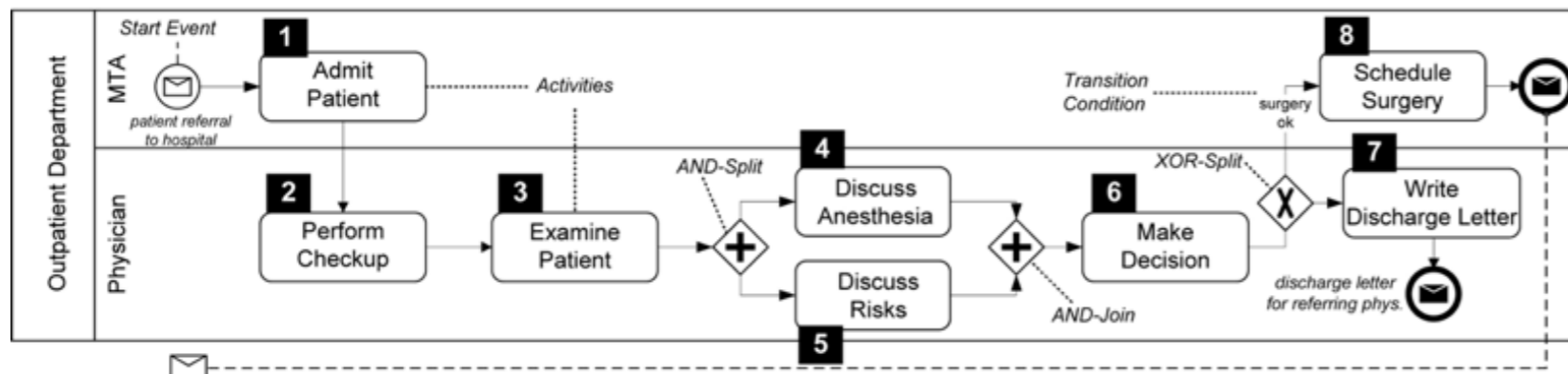
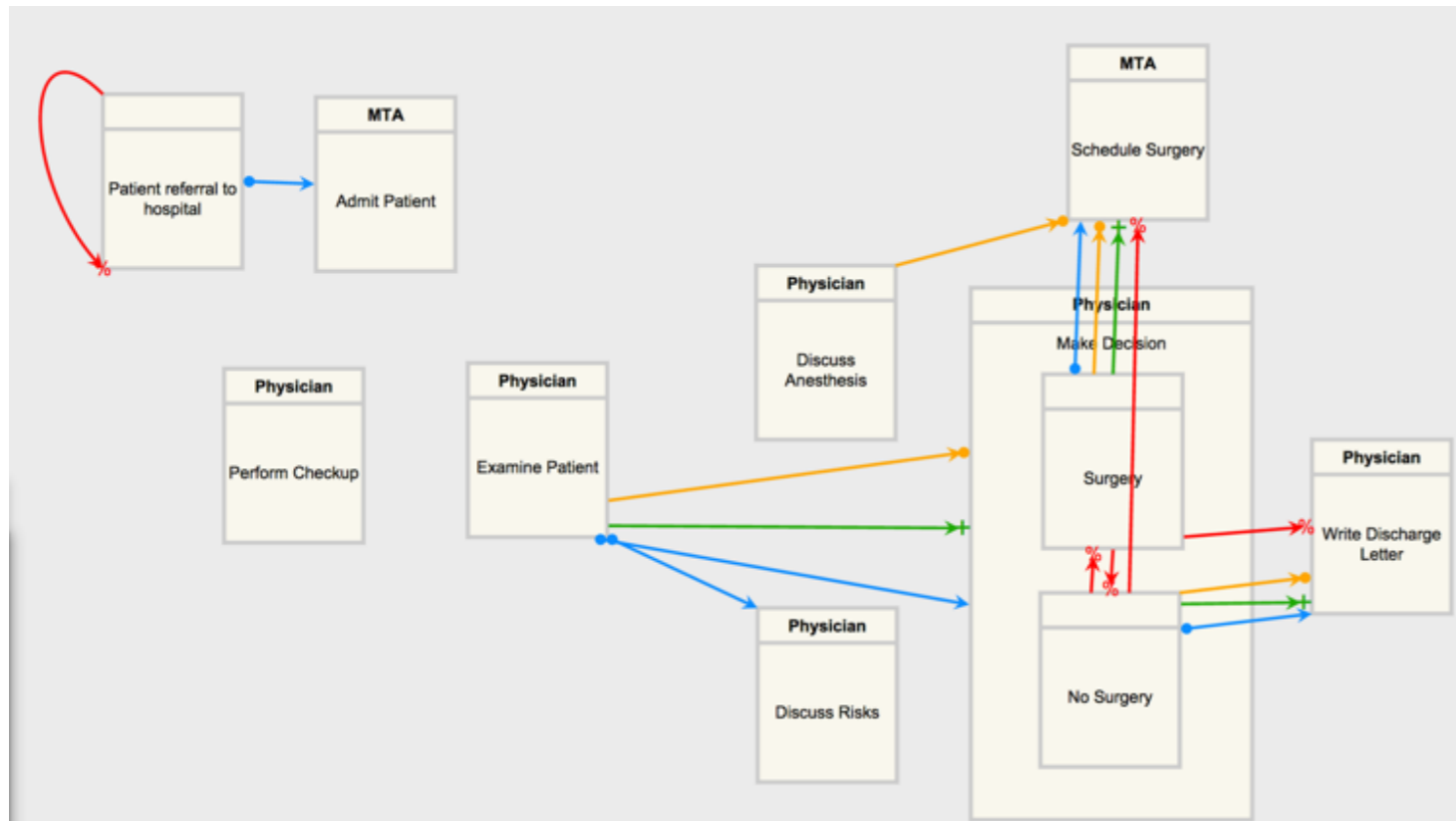


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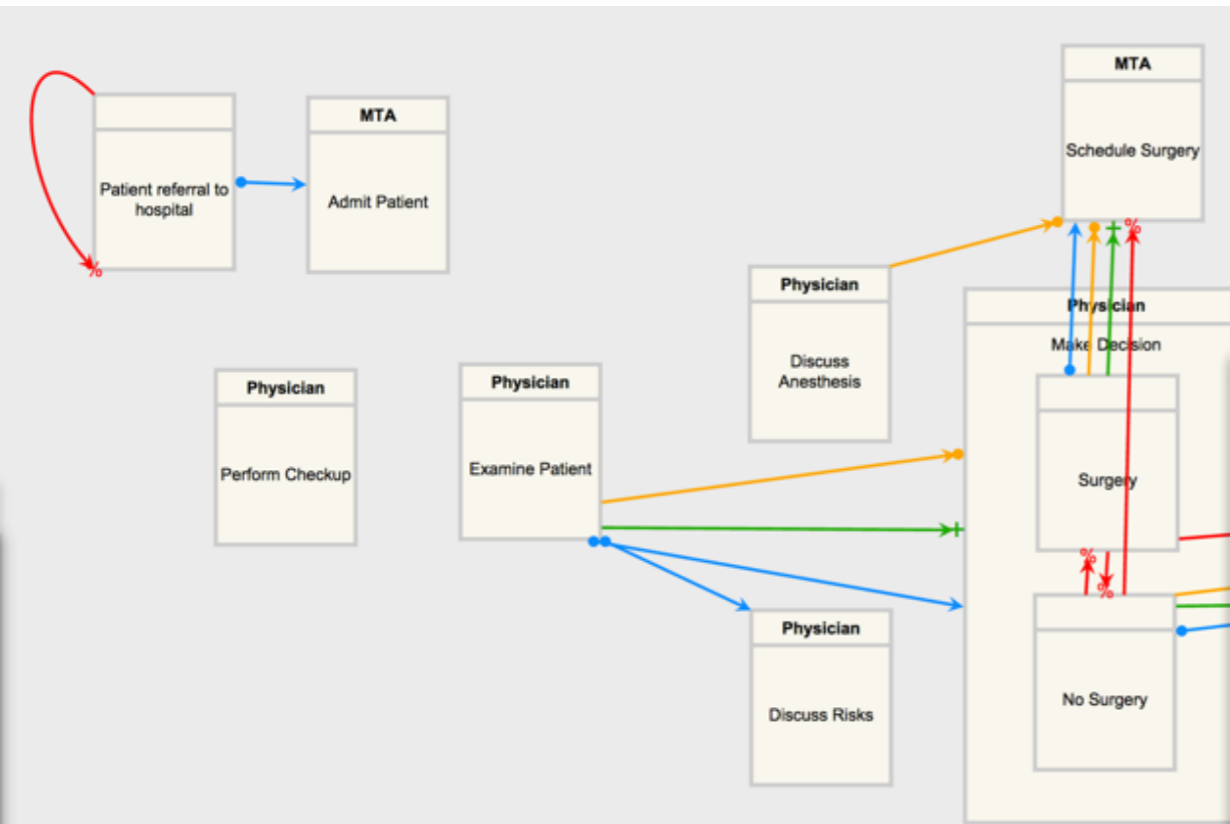
This is a Dynamic Condition Response (DCR) graph

[PLACES2010,Phd11,SEFM2011,DEBS12,EDOC2013,JLAP82,2013,BPM2013-15,PhD15,FM15]

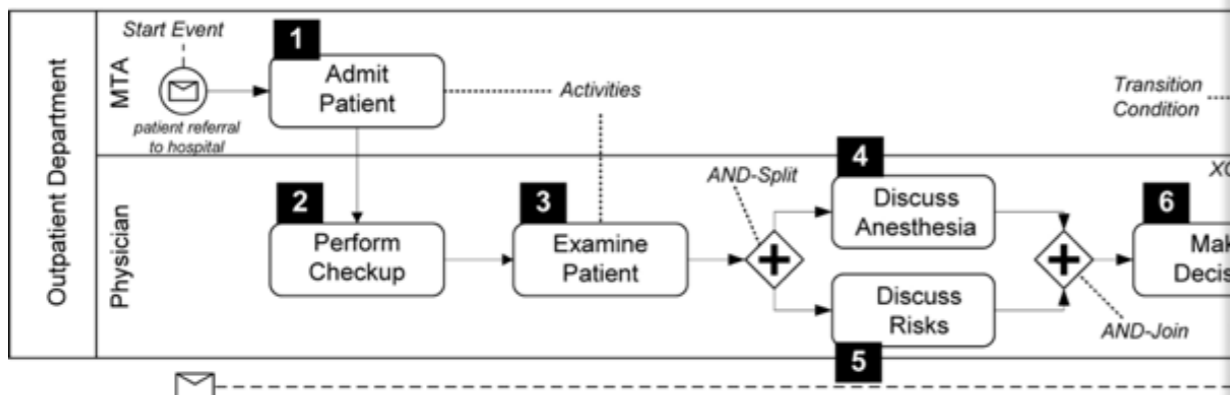
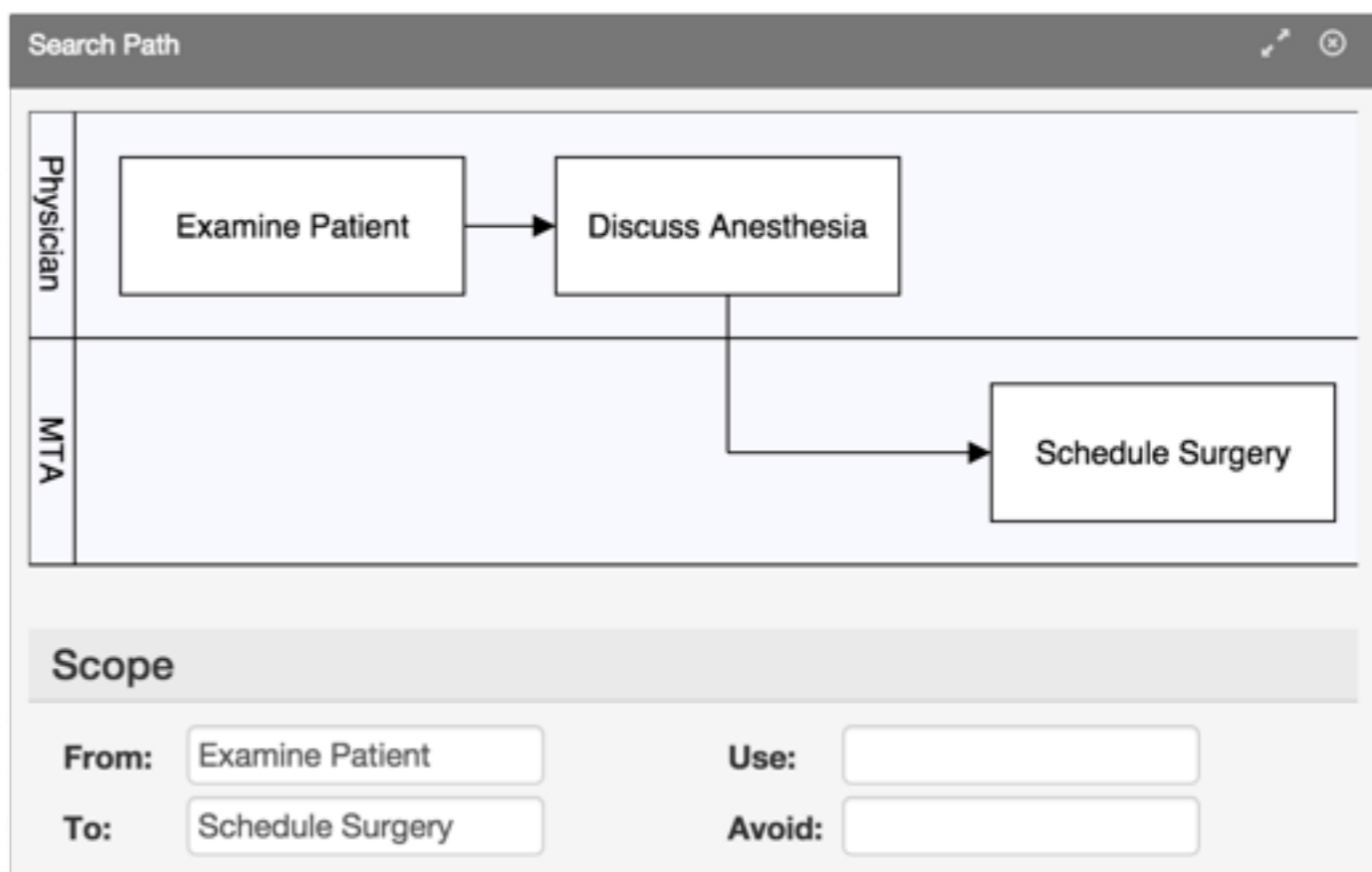
Why DCR Graphs and not flows?



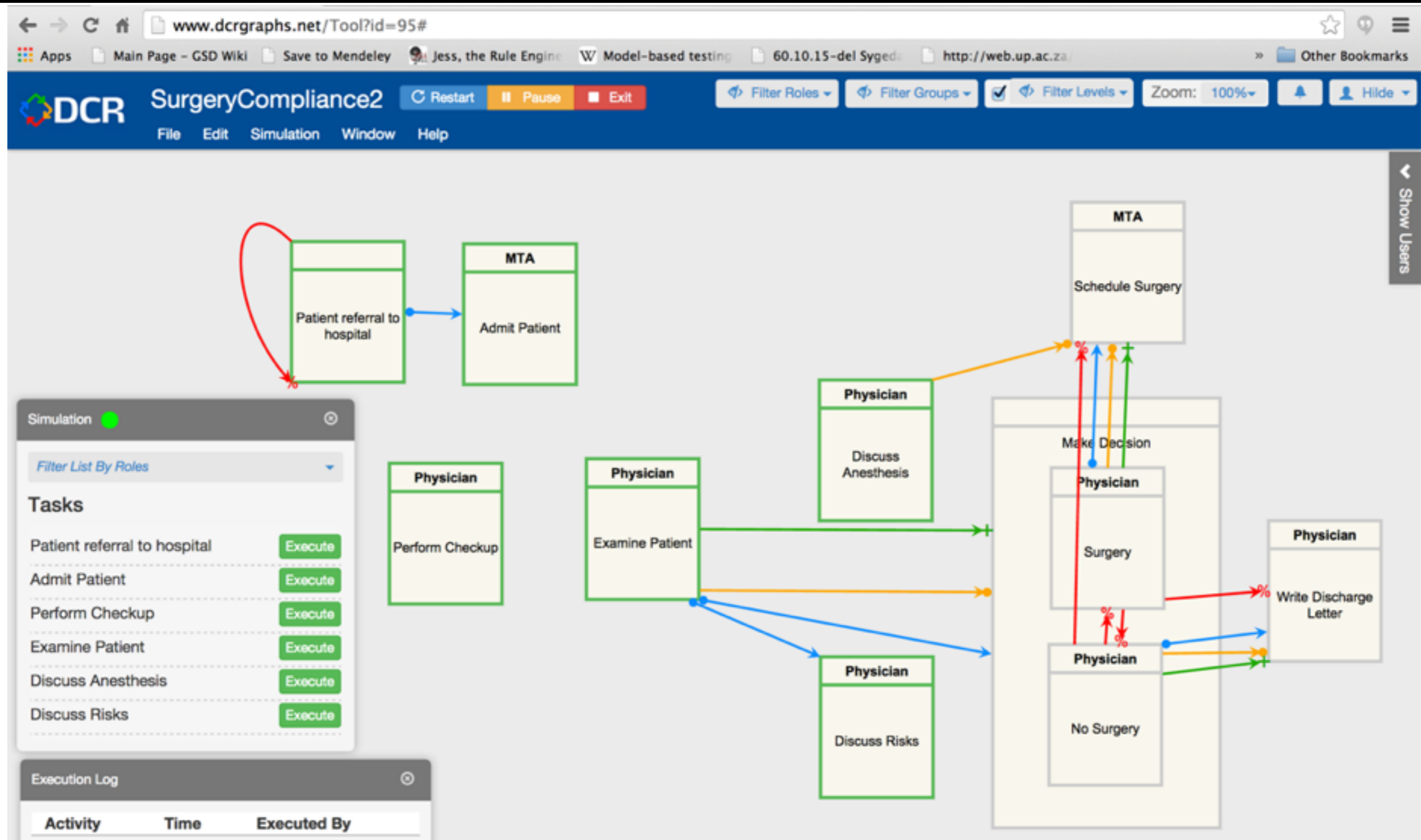
Why DCR Graphs and not flows?



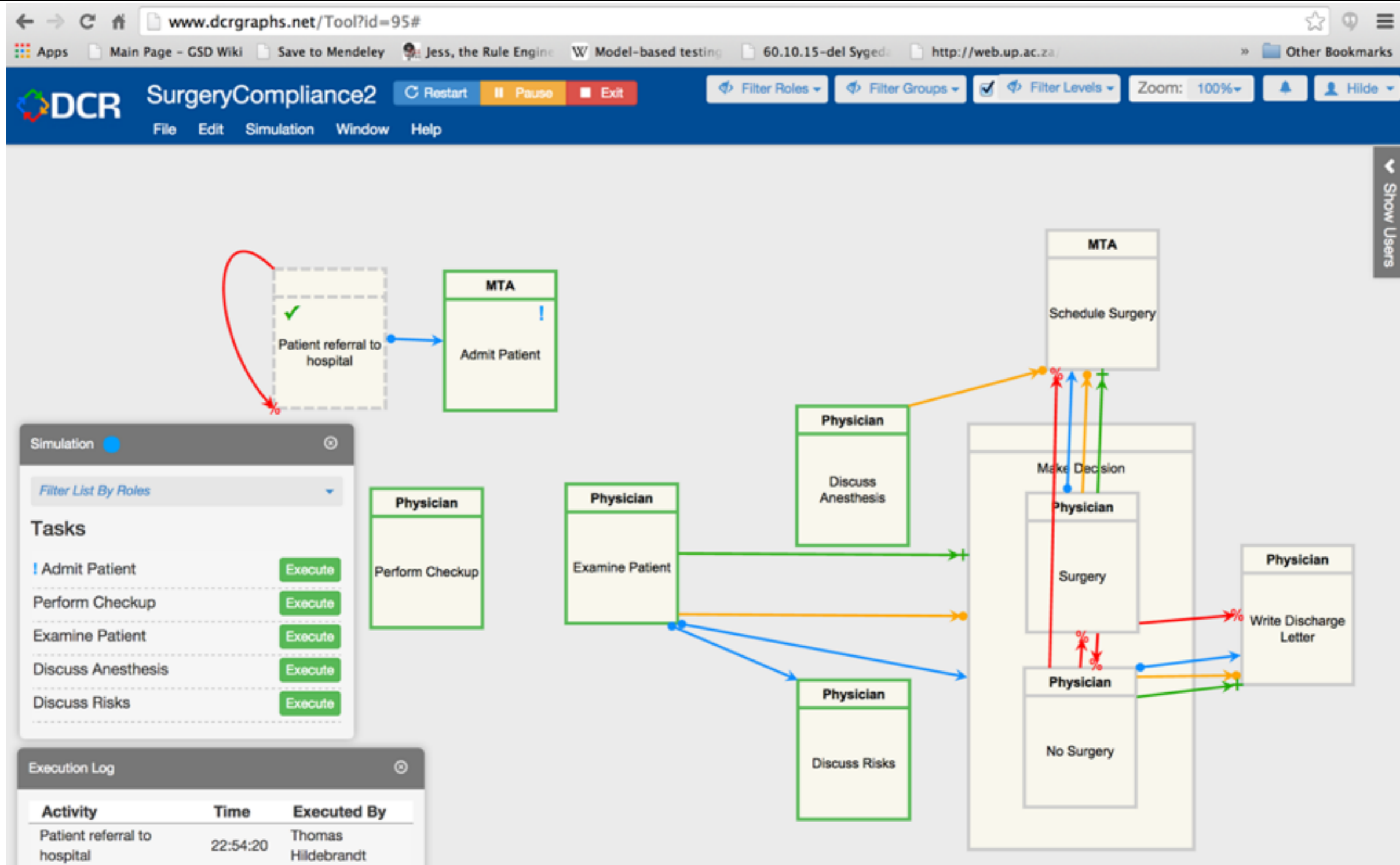
Flexible, adaptable & captures “why”
The system can compute “how”:



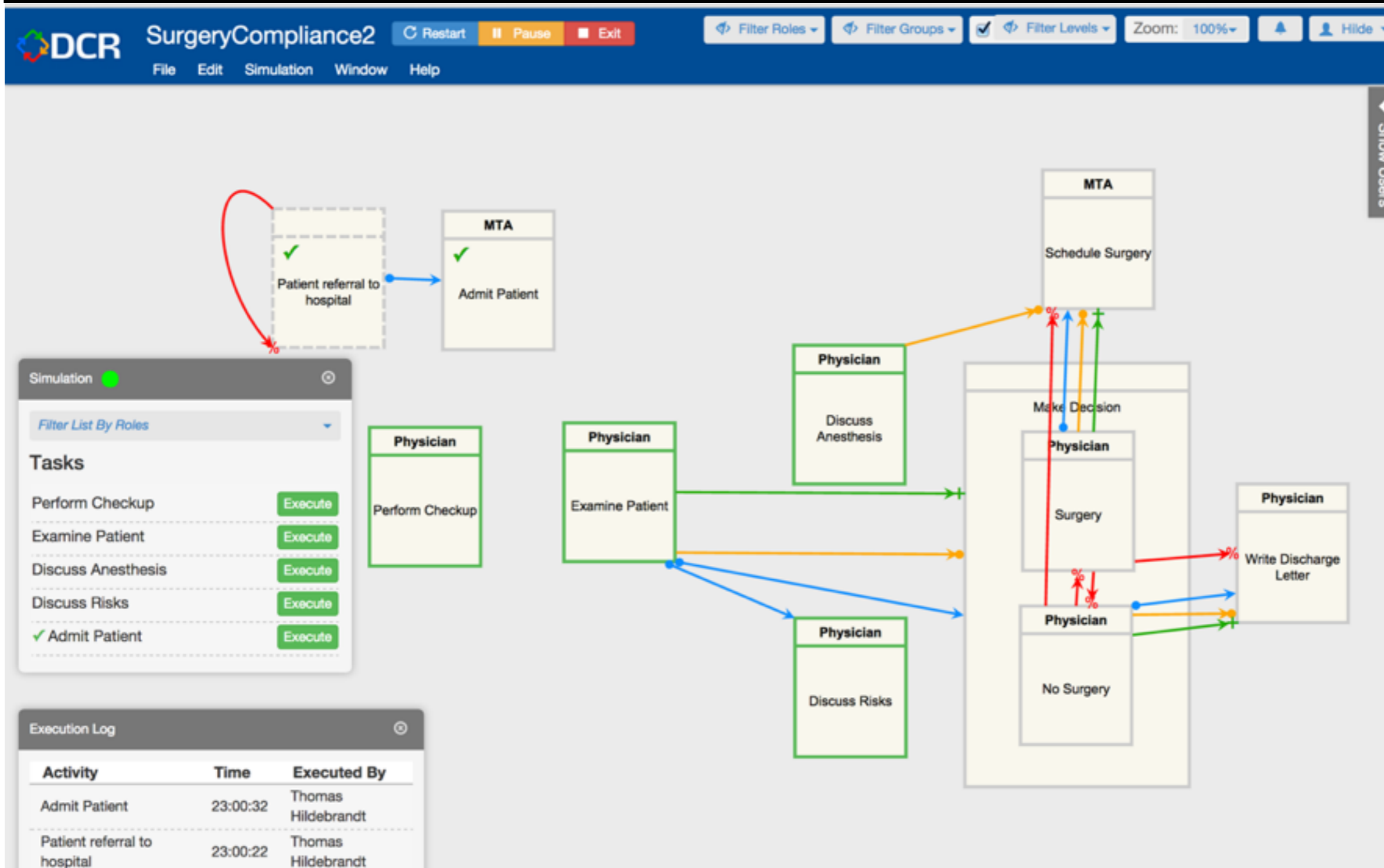
Validate design by simulation



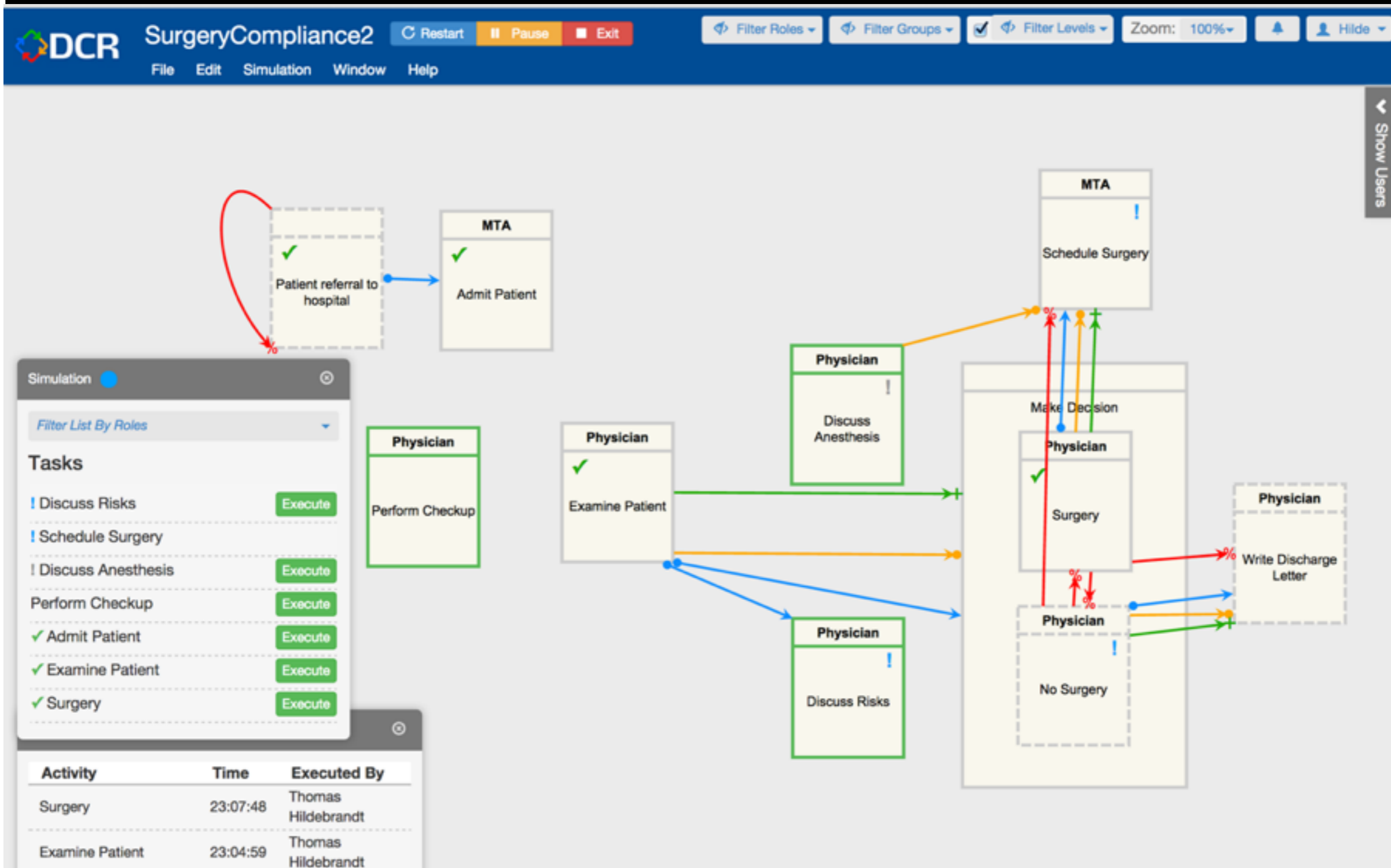
State is visible as familiar



State is visible as familiar

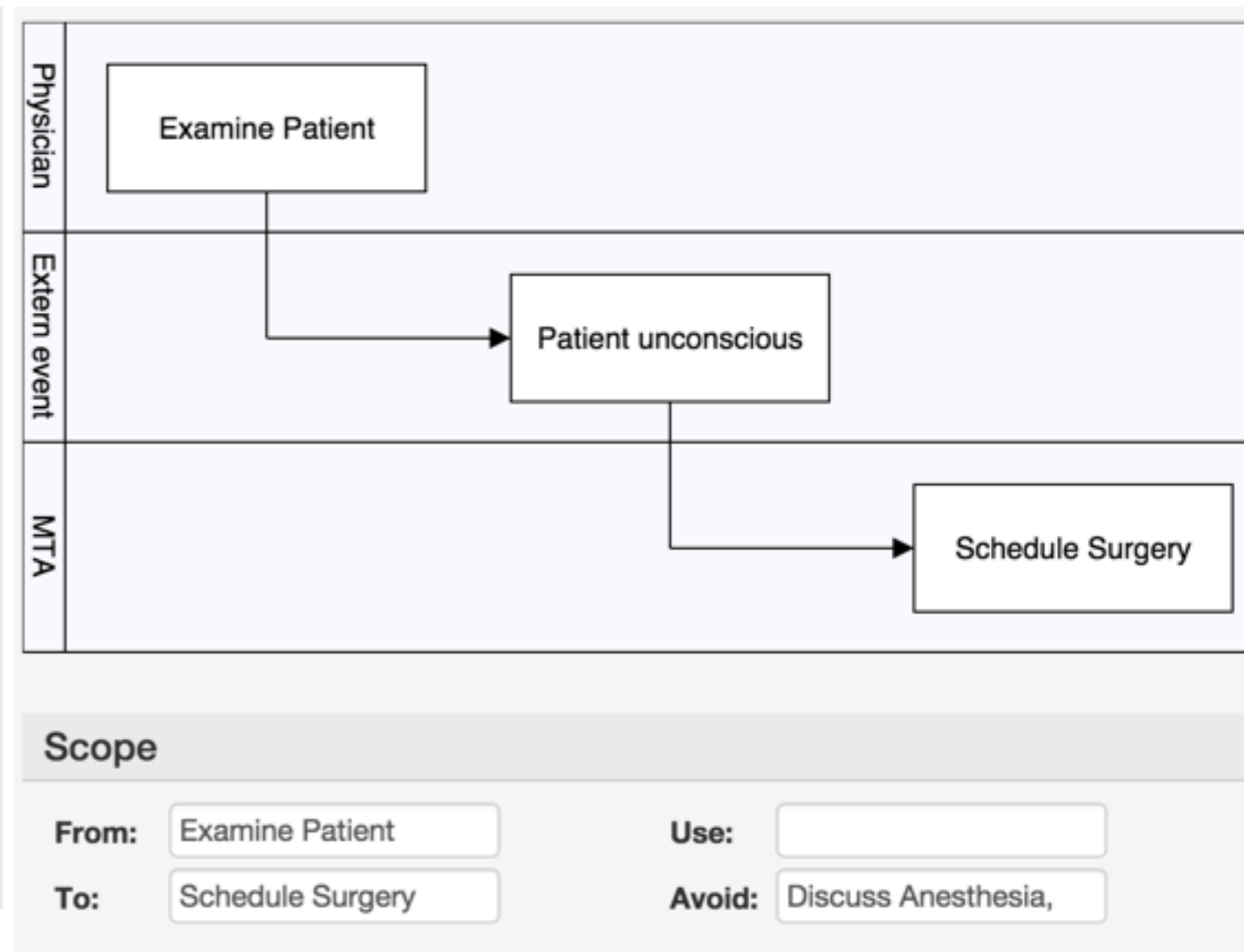


State is visible as familiar

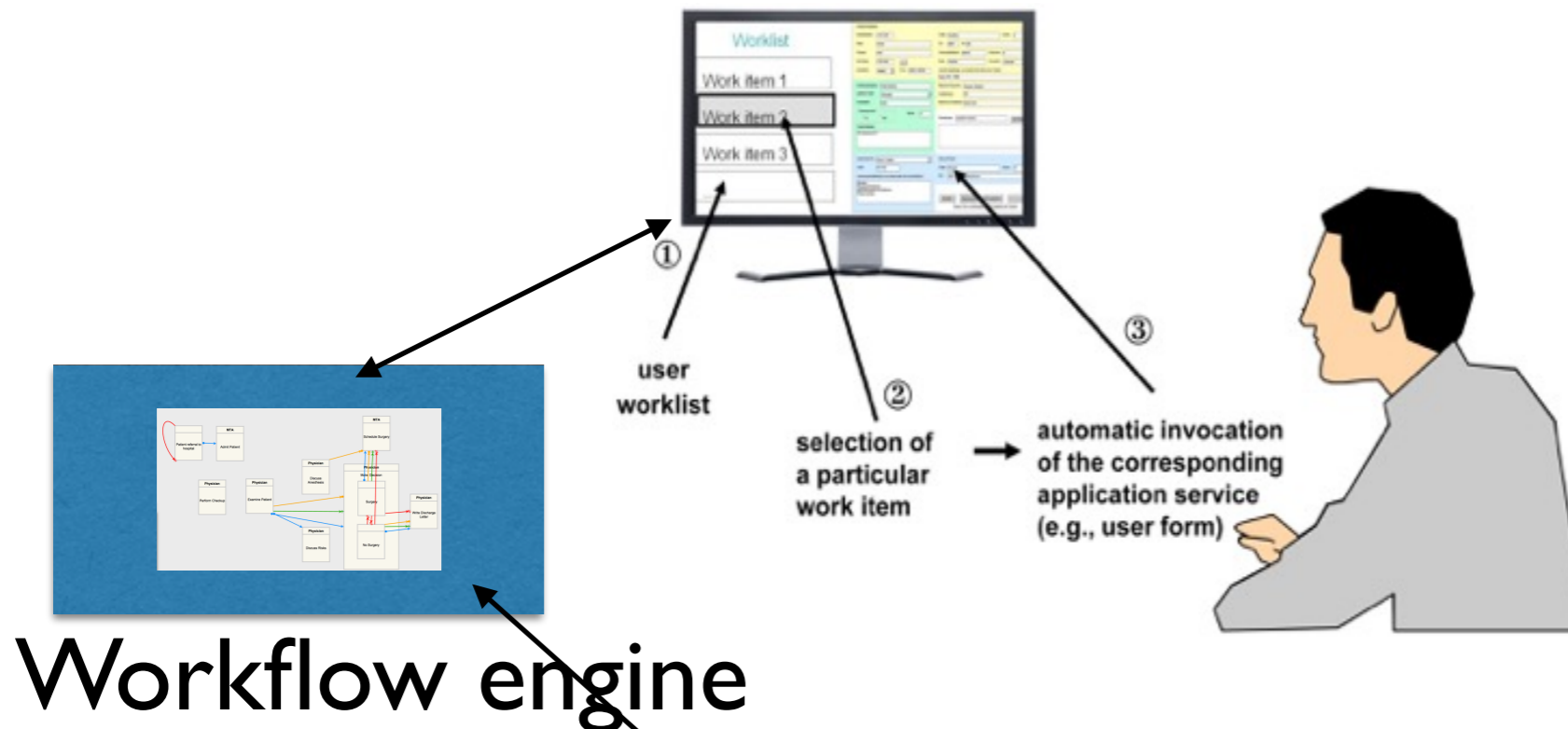


Different uses of DCR Graphs

Modelling & Validation



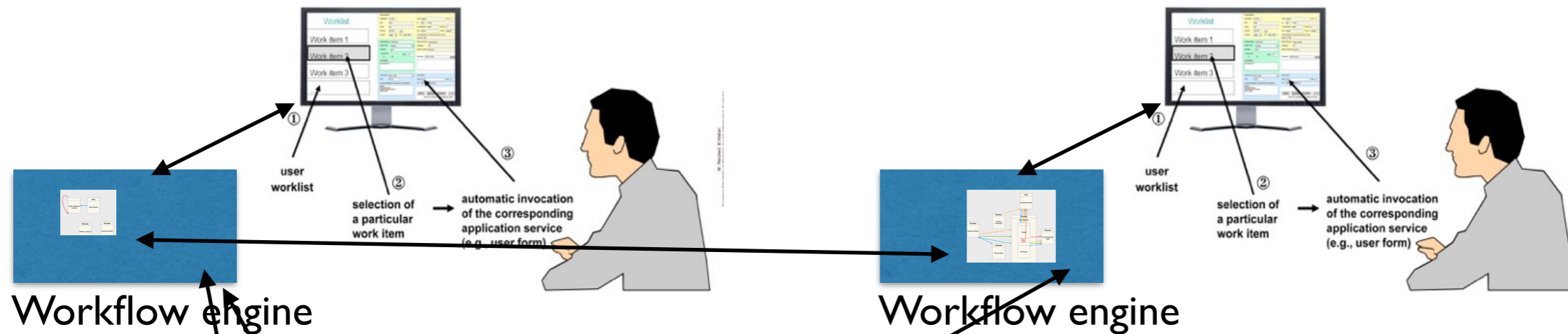
DCR Graphs for execution



Papers: [ACMI5, BPM13-15]

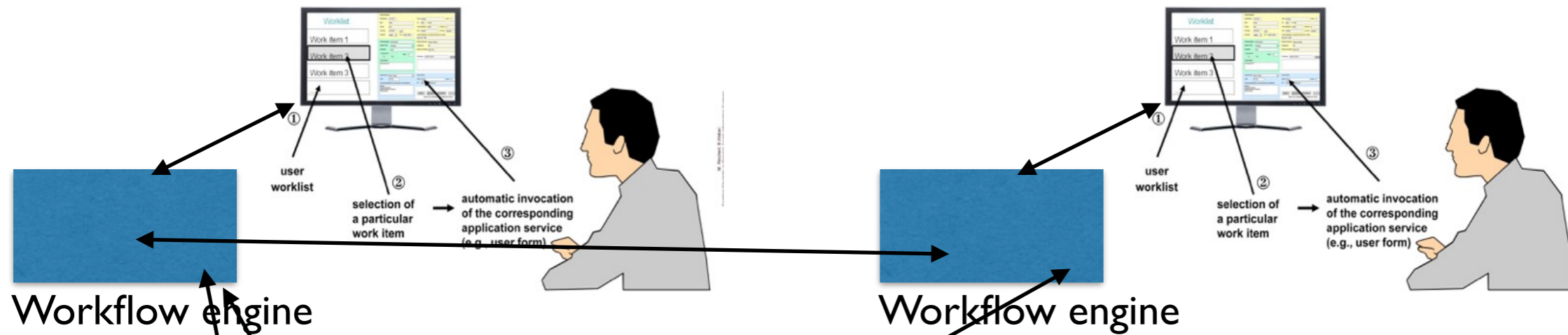


Seamless & safe distribution



Papers: [SEFM2011, FHIES2011, BPM15]

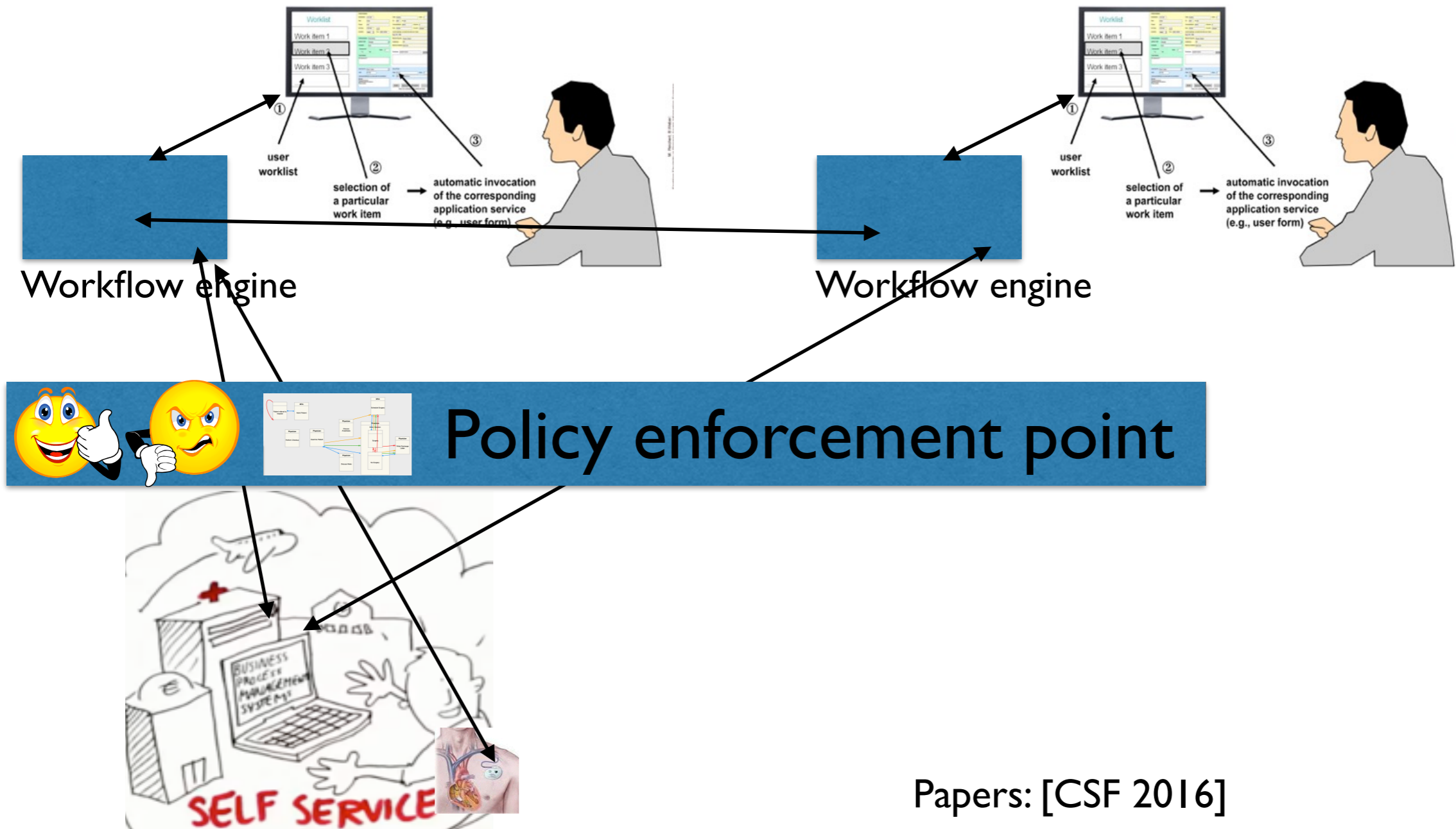
Monitoring & Compliance



Run-time monitor

Papers: [R. Mukkamala PhD,CSF 2016]

Policy enforcement



Papers: [CSF 2016]

What is special for DCR

What is special for DCR

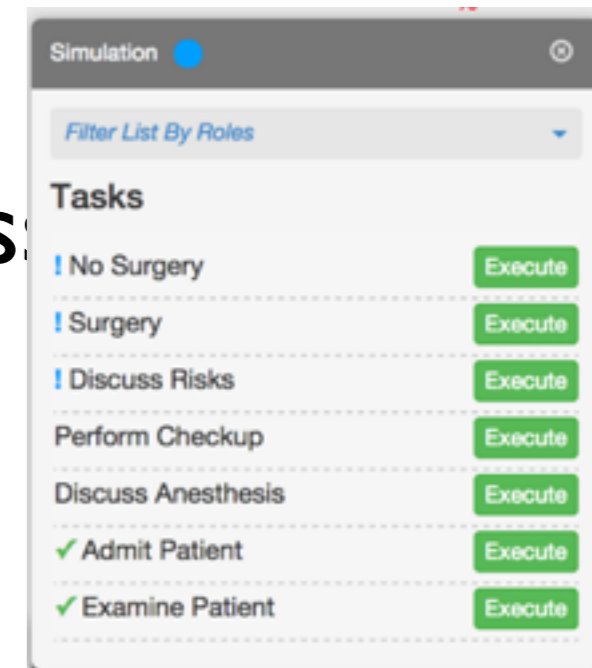
- Formal and close to natural language:
Conditions, Responses, Inclusions and Exclusions

What is special for DCR

- Formal and close to natural language:
Conditions, Responses, Inclusions and Exclusions
- Expressive and decidable:
Can express all regular safety and liveness properties

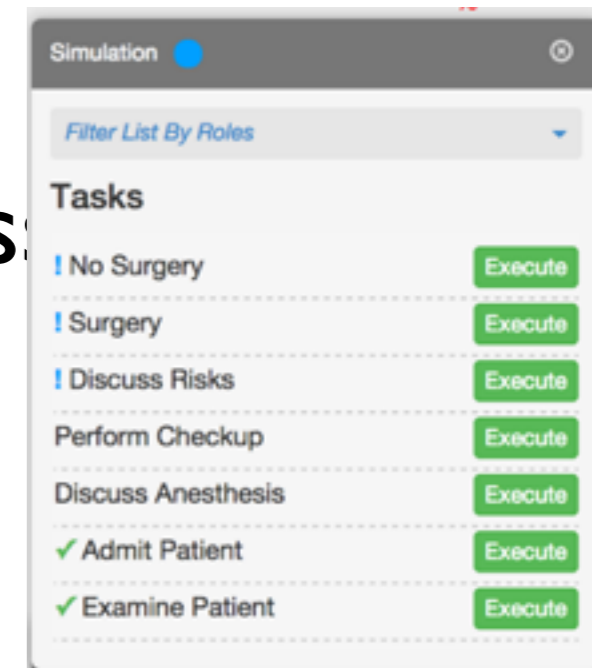
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Run-time state as “check-list” on events



What is special for DCR

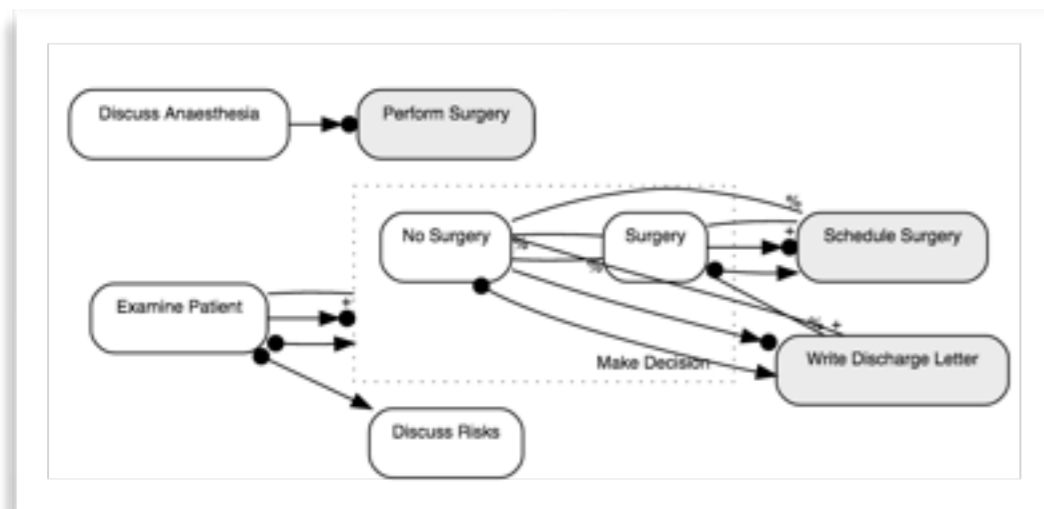
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- Expressive and decidable:
Can express all regular safety and liveness
- Operational and understandable:
Run-time state as “check-list” on events
- Efficient distributed monitoring & enactment
Local decision of enabledness & effect of events



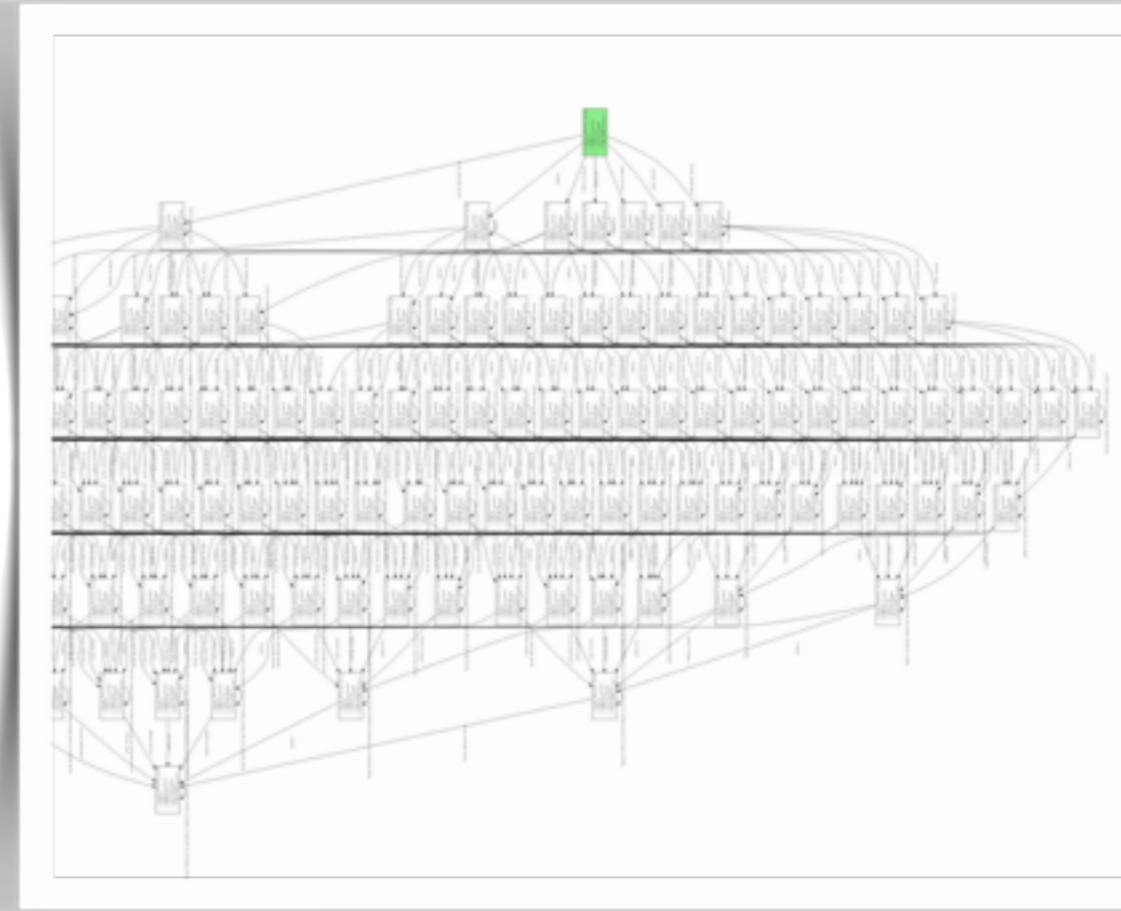
Work so far

- Tools (DCRGraphs.net, dcr.tools)
- Verification, Time & Dynamic Subprocesses [JLAP82,2013, BPM14,FMI5]
- Distribution & Independence [SEFM2011,BPM15]
- Search Path & projections [BPM14], traceability [dcr.itu.dk]
- Applications to case studies [FHIES2011,ACM14,BPM15,S4CIP16]
(Healthcare, funding agency, finance & emergency management)
- Run-time adaptation, refinement & enforcement [EDOC2013][ACM14][FMI5][CSF16]
- Programming Language, Data & Forms [DEBS2012,REBLS15, BPM CASE 2016]

Dealing with state space



VS



- Safe distribution & infer concurrency [SEFM2011, BPM15]
- Modularity & step-wise refinement [FM15]
- Static analysis for reachability & enforceability [CSF15]

Timed DCR Graphs

Eventually is often not good enough....



Timed DCR Graphs

Eventually is often not good enough....



and delays may be required



Timed DCR Graphs

Eventually is often not good enough....



and delays may be required



Timed DCR Graphs introduce
delays on conditions, and *deadlines* on responses

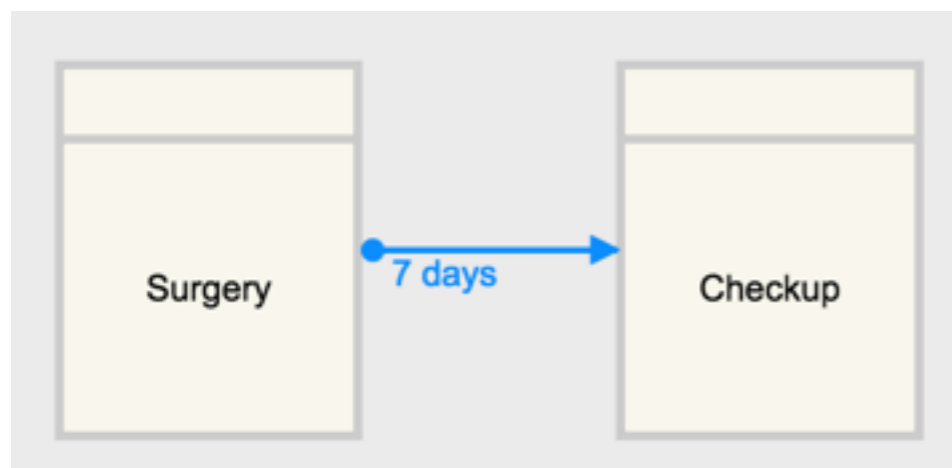
[JLAP82,2013,
CSF2016]

Delays & Deadlines

“After eating you must wait 12 hours before surgery”



“After surgery, a checkup must be done within 7 days”



Enforceability & Escalation

Some events are uncontrollable



in particular progress of time and human activities

Enforceability & Escalation

Some events are uncontrollable



in particular progress of time and human activities

Oh Cinderella, when I said midnight I meant midnight. Now let's see if I can get you out of this...



Need compensation/escalation & pro-active enforcement [CSF2016]

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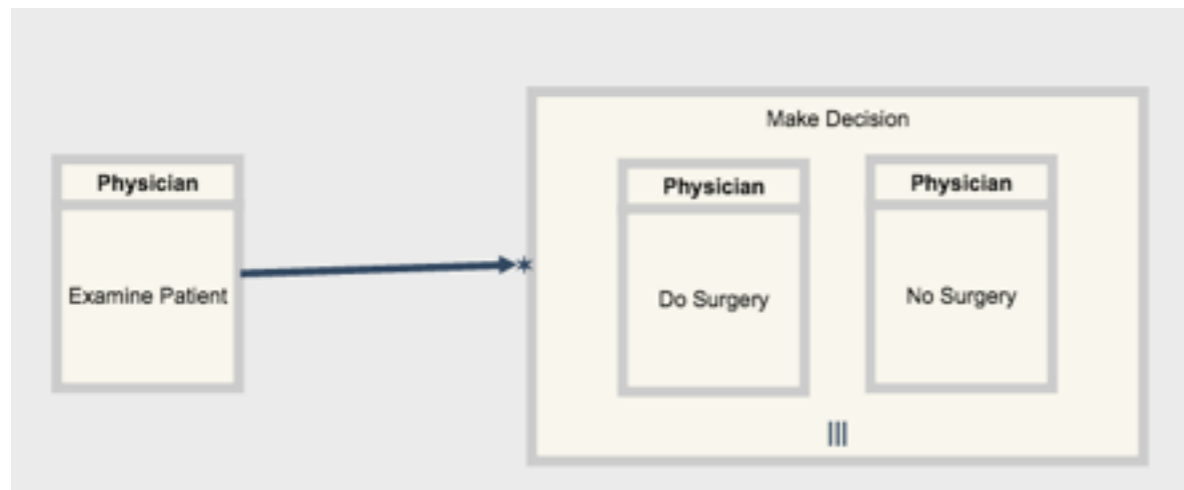
Need compensation/escalation & pro-active enforcement [CSF2016]



Try research-prototype at dcr.tools/obligations

Sub processes & infinity

- Dynamically spawned sub processes



- supported in theory and tools - but makes termination undecidable [FM15]
- not a problem for enactment, run-time monitoring & (some) static analysis [FM15]

Current Work

- Case studies, expressiveness & usability
- Better static approximation of reachability
Types for progress
- Data and Declarative Forms
- Security elicitation & compliance
- Process mining for prescriptive processes

Data & Declarative Forms

Reimbursement Claim

Approve or reject *

Select ▾

Submit

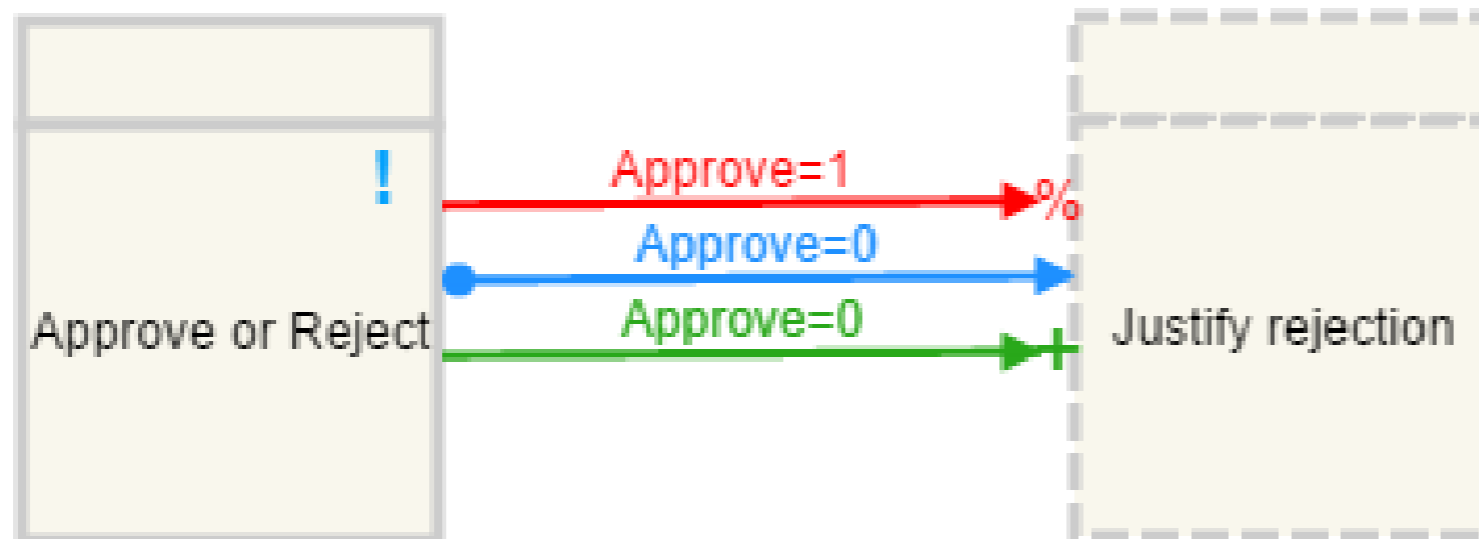
Reimbursement Claim

Approve or reject *

Reject ▾

Justify rejection *

Submit



Data & Declarative Forms

Reimbursement Claim

Approve or reject *

Select ▾

Submit

Approve=null

JustifyRejection=null

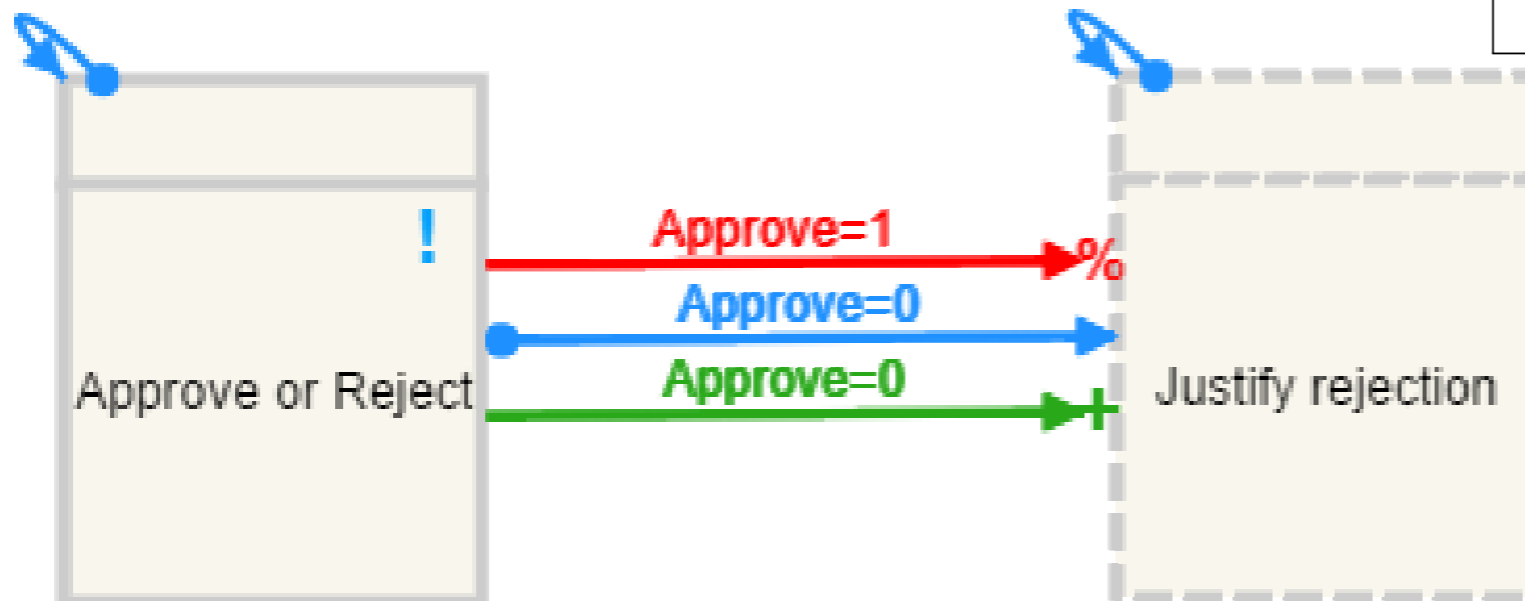
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Data & Declarative Forms

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Approve=null

JustifyRejection=null

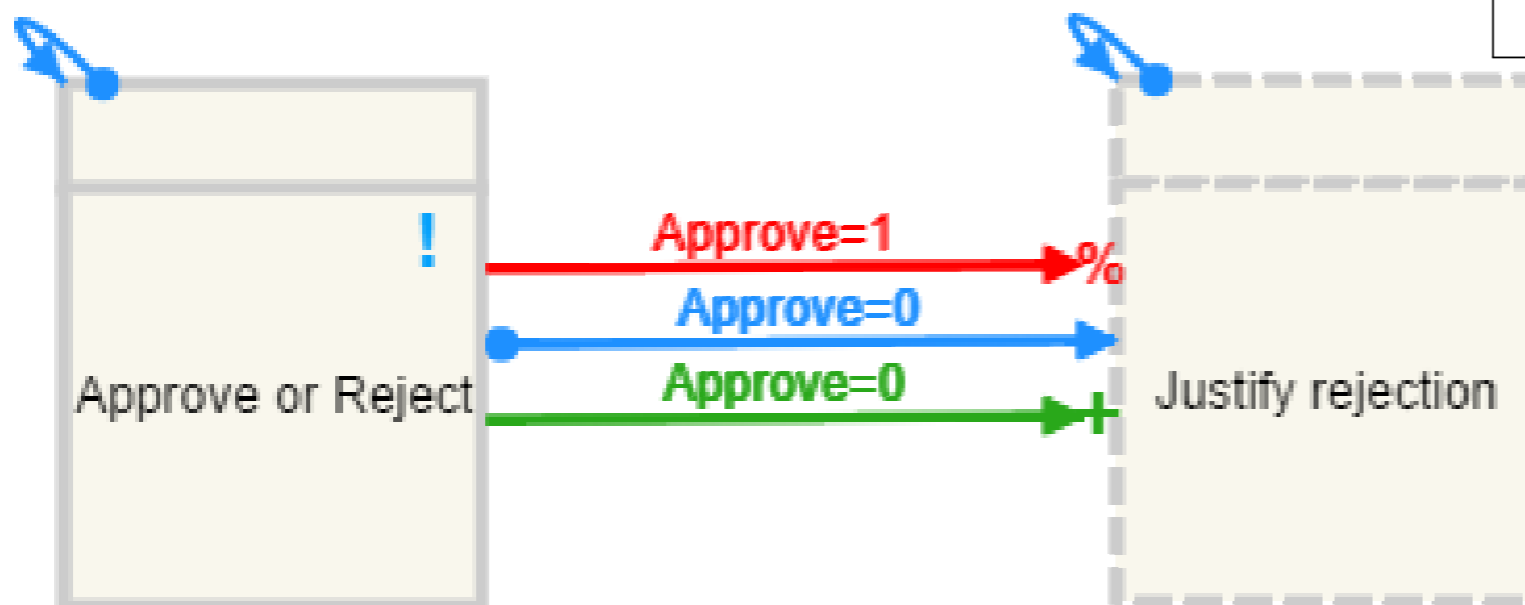
Reimbursement Claim

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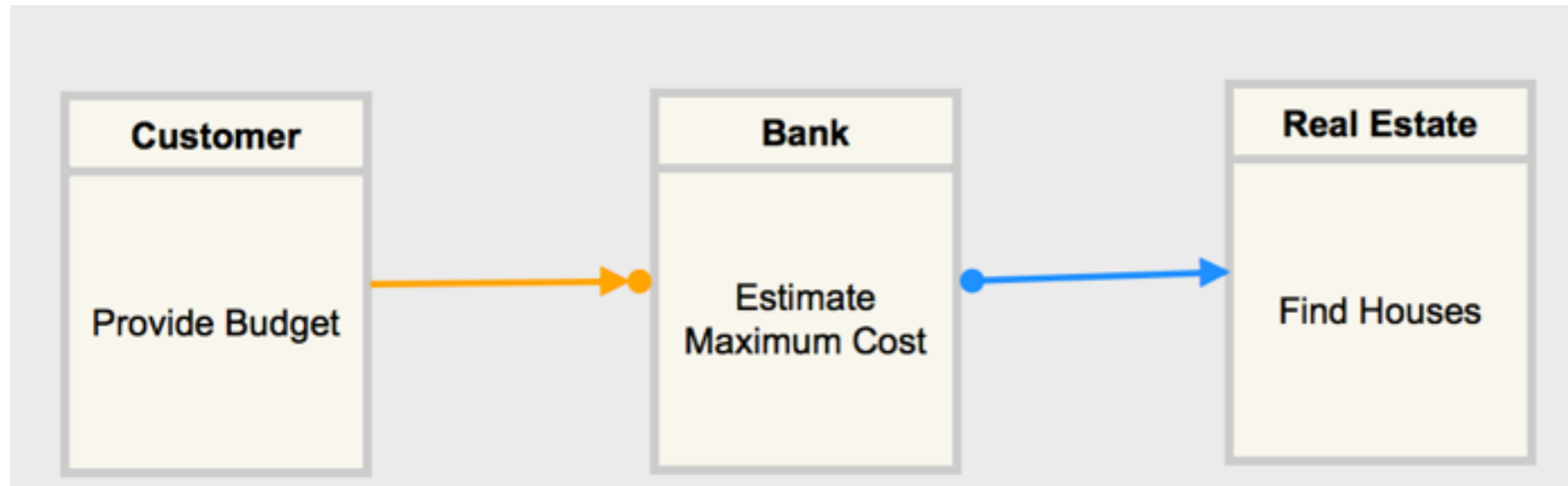
Justify rejection *

Submit

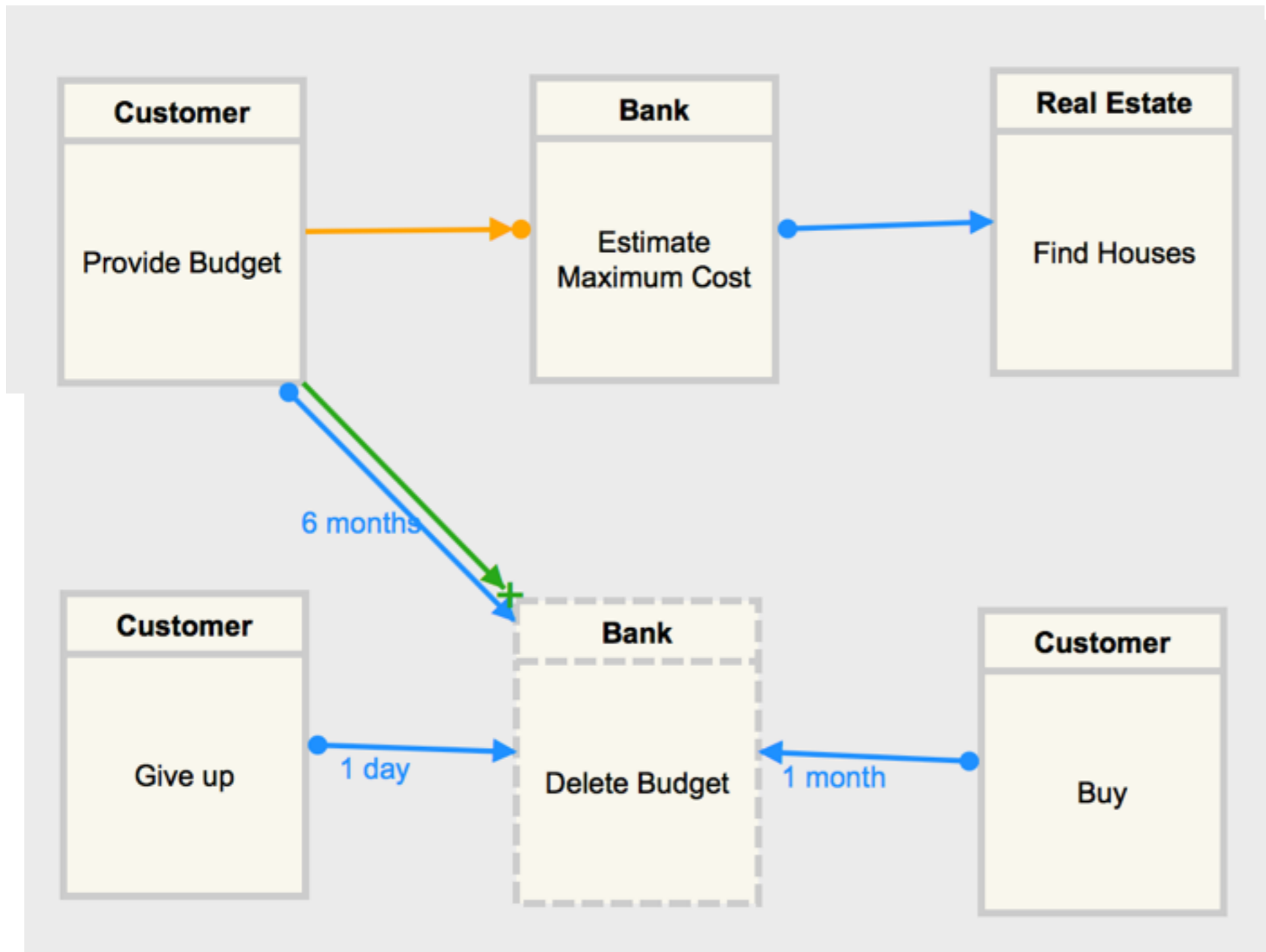


Forms are Declarative Processes! [BPM Case paper 2016]

Security Elicitation



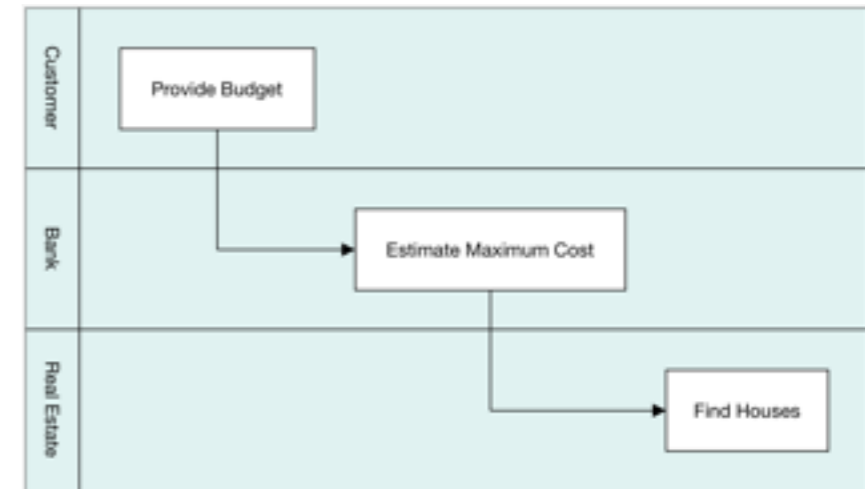
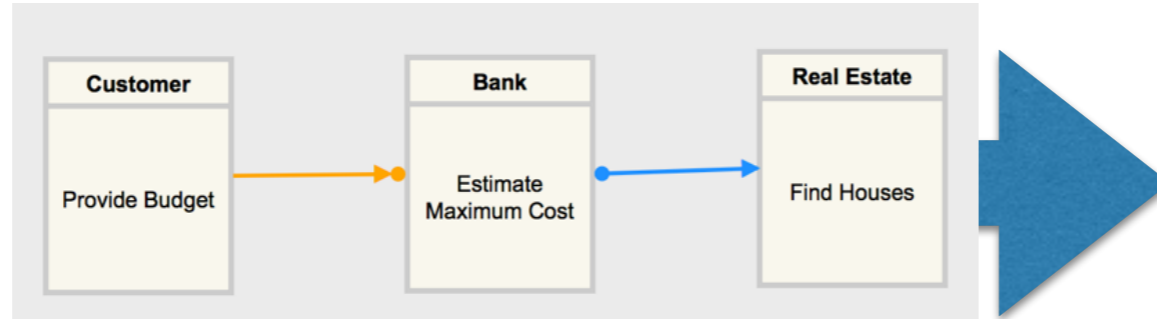
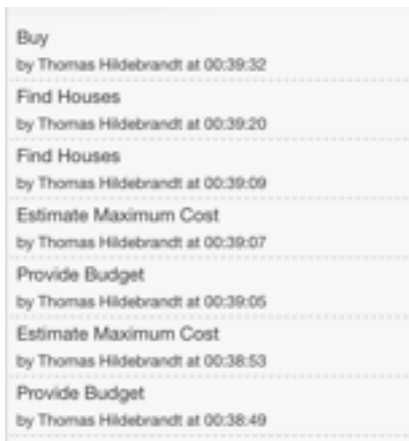
Security Elicitation



(EU General Data Protection Requirement)

Mining Declarative Processes

(work in progress, SAC 2017)

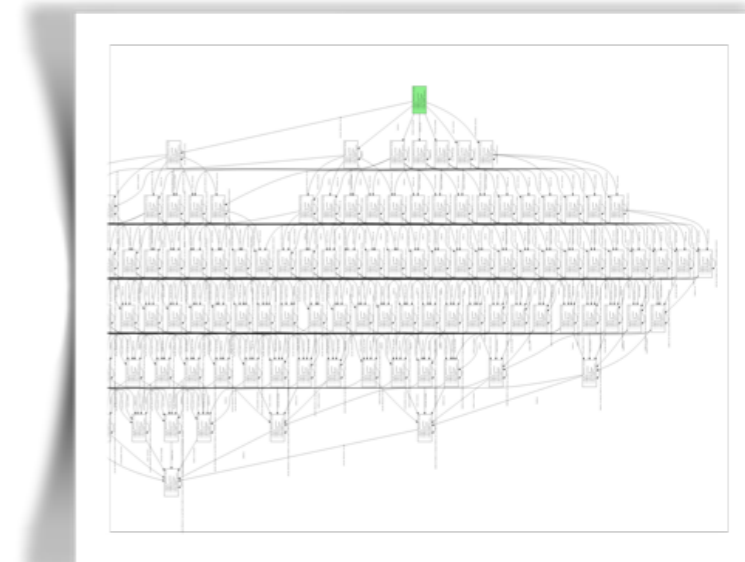


Process log

Statistically inferred constraints

Inferred flows

Avoid mined spaghetti diagrams



Mining for Prescriptive BPM

https://youtu.be/7oat7MatU_U

(work in progress)

Process log

Buy
by Thomas Hildebrandt at 00:39:32
Find Houses
by Thomas Hildebrandt at 00:39:20
Find Houses
by Thomas Hildebrandt at 00:39:09
Estimate Maximum Cost
by Thomas Hildebrandt at 00:39:07
Provide Budget
by Thomas Hildebrandt at 00:39:05
Estimate Maximum Cost
by Thomas Hildebrandt at 00:38:53
Provide Budget
by Thomas Hildebrandt at 00:38:49



Mined evidence-based routes

We collaborate with danish municipality and major provider of eGovernment solutions

Conclusions

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- Flow-graphs like BPMN are often too inflexible, do not capture *why* and are difficult to adapt & maintain

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Conclusions

- Flow-graphs like BPMN are often too inflexible, do not capture *why* and are difficult to adapt & maintain
- DCR graphs support flexibility, adaptability and formal validation of compliance and correctness
- Tool support & applied with success in industry
- Still challenges!
- But promising initial work on understandability, refinement, static analysis & applications to collaborative design, validation and training