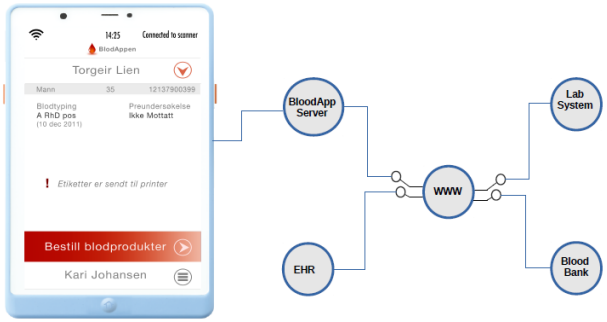
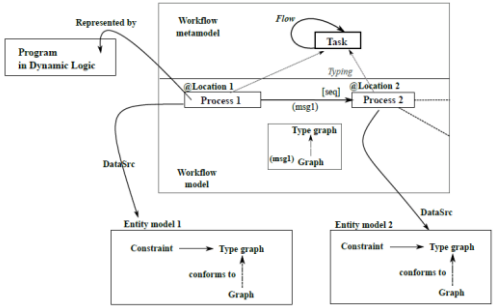
Towards a Multi Meta-modelling Approach for Developing Distributed Healthcare Applications





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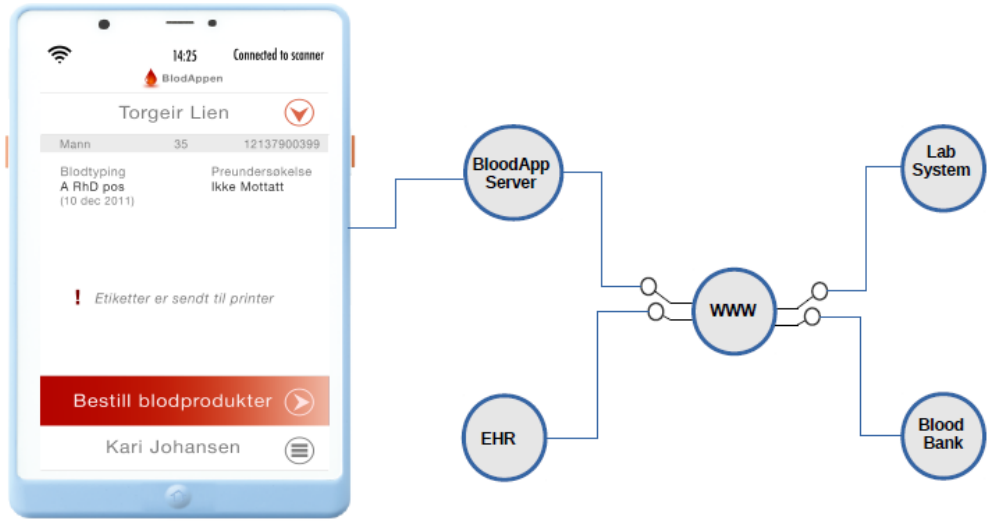
Healthcare Systems and IT

- **Involves the organisation of:**
  - People: healthcare personnel, patients, …
  - Institutions: hospitals, emergency services, doctor's office,…
  - Resources: equipment, medical supplies, biological material,…

- **IT systems for healthcare services must:**
  - Integrate with external healthcare systems and services.
  - Support electronic forms of capturing patient information.
  - Adapt to different settings and the use of different services.
  - Support workflows following prescribed standards.
  - Be adaptable to changes in rules and regulations.

Blood Transfusion Application

- **Application being developed in collaboration with Helse Bergen and Helse Vest IKT:**



1. **Read** identity of patients from wristbands.
2. **Access** Electronic Health Record (EHR) to determine blood type.
3. **Print** tags for blood samples to be sent to the laboratory.
4. **Order** blood from blood bank based on patient identity or tags.
5. **Send** screening results from laboratory to the blood bank.
6. **Match** patient identity and blood samples (safety).
7. **Record** any complications related to blood transfusion.

- **A distributed application required to support and conform to a highly regulated work process.**

Model Driven Engineering

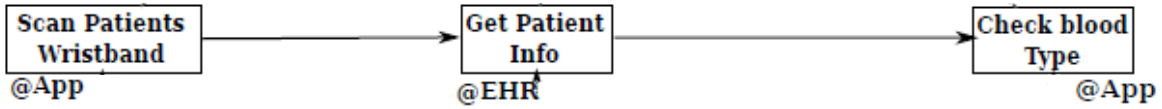
- A **model-centric approach** to software engineering:

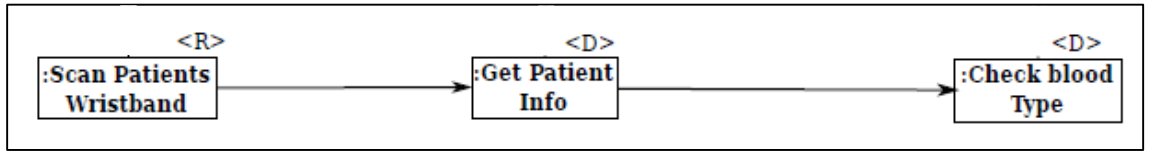
Meta-modelling:
Defining domain-specific modelling languages.

M2M/M2T transformations:
Model refinement, model execution, code generation.

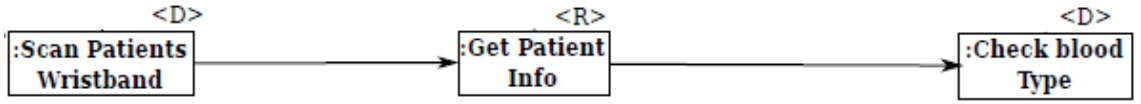
Simulation and verification:
Validate the correctness of models and designs.

Models





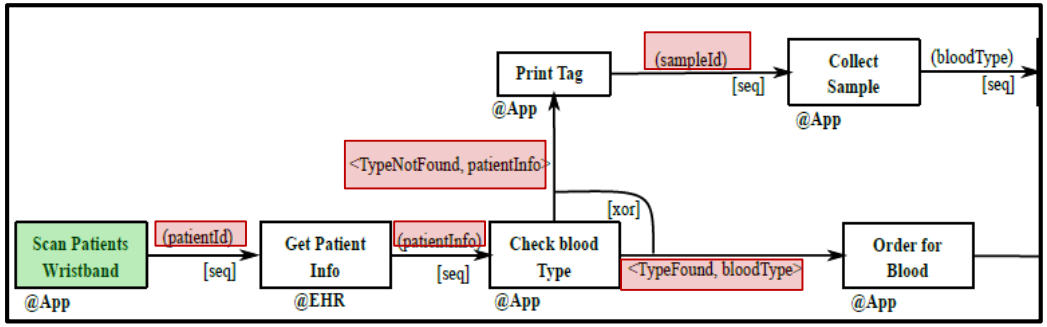
Model transformations

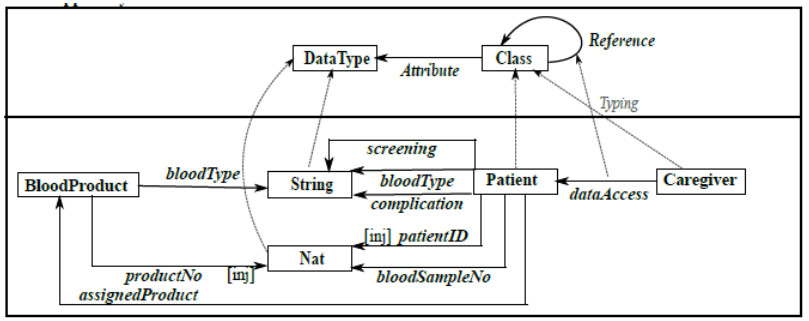


Distributed Healthcare Apps

- **Modelling a distributed healthcare application requires multiple modelling languages:**
  - **Workflow modelling** –
    for modelling the underlying work process of the application.
  - **Data entity modelling** –
    for modelling the data and information being processed.
  - **Message passing modelling** –
    for modelling the exchange of data between processes.

Multi meta-modelling



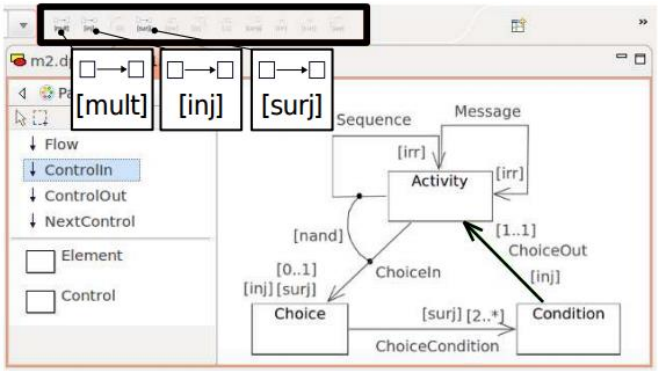


- **Coordination*** **for coherent linkage of models belonging to the different modelling languages.**

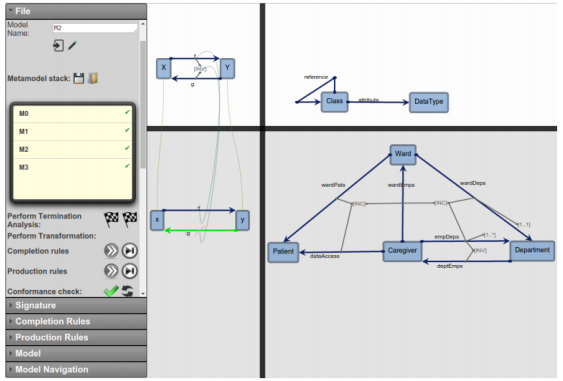
***** F. Rabbi, Y. Lamo, and W. MacCaull. Co-ordination of Multiple Metamodels, with Application to Healthcare Systems. In EUSPN/ICTH 2014: pp. 473-480

Diagram Predicate Framework

- **Formal foundation for meta-modelling, model coordination, and model transformation:**
  - A graph-based diagrammatic approach to meta-modelling.
  - Conformance (typing) based on graph homomorphisms and on predicates expressing additional model constraints.
- **Supported by the DPF Workbench and WebDPF:**

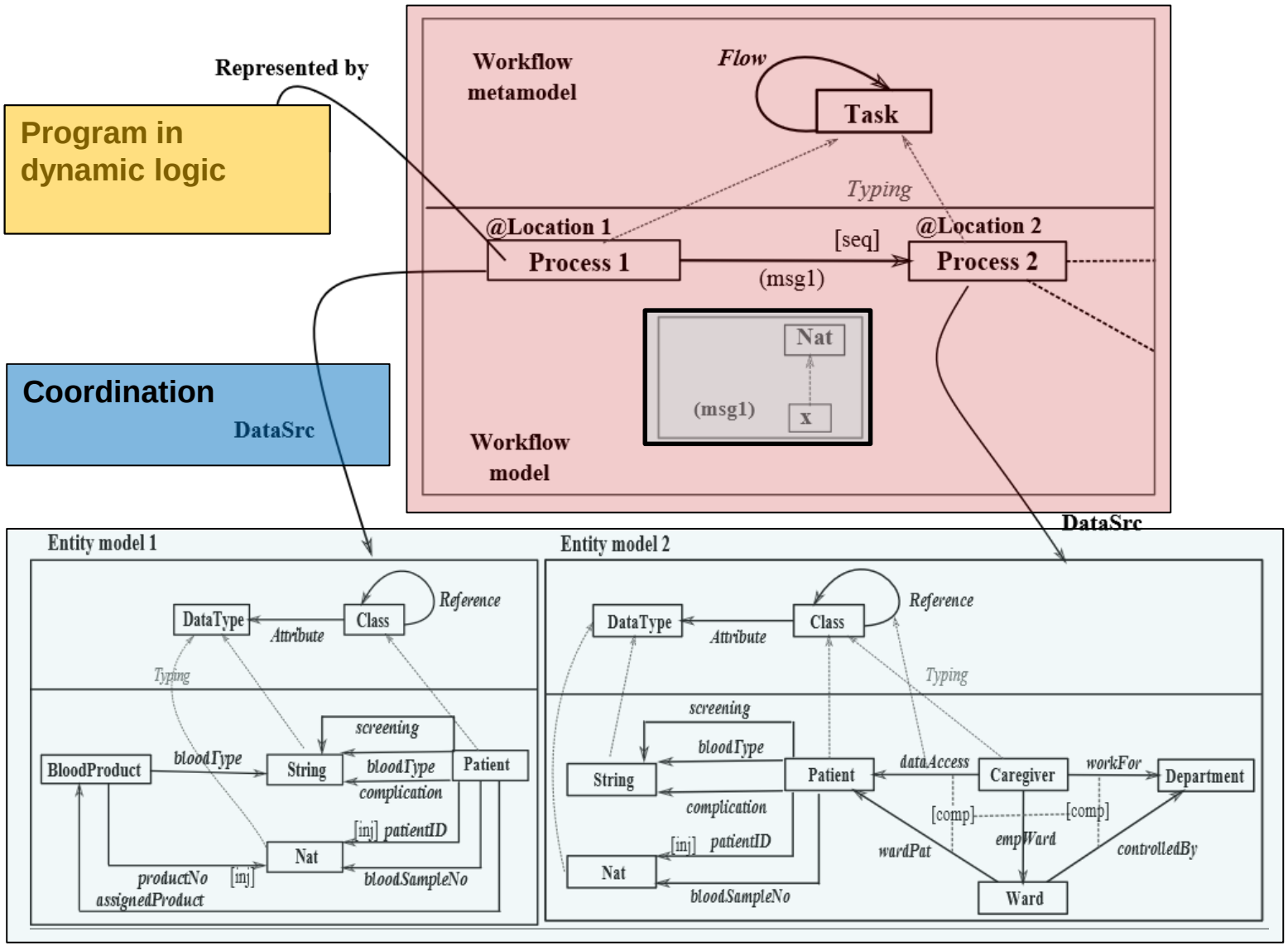


Eclipse EMP-based
[http://dpf.hib.no]



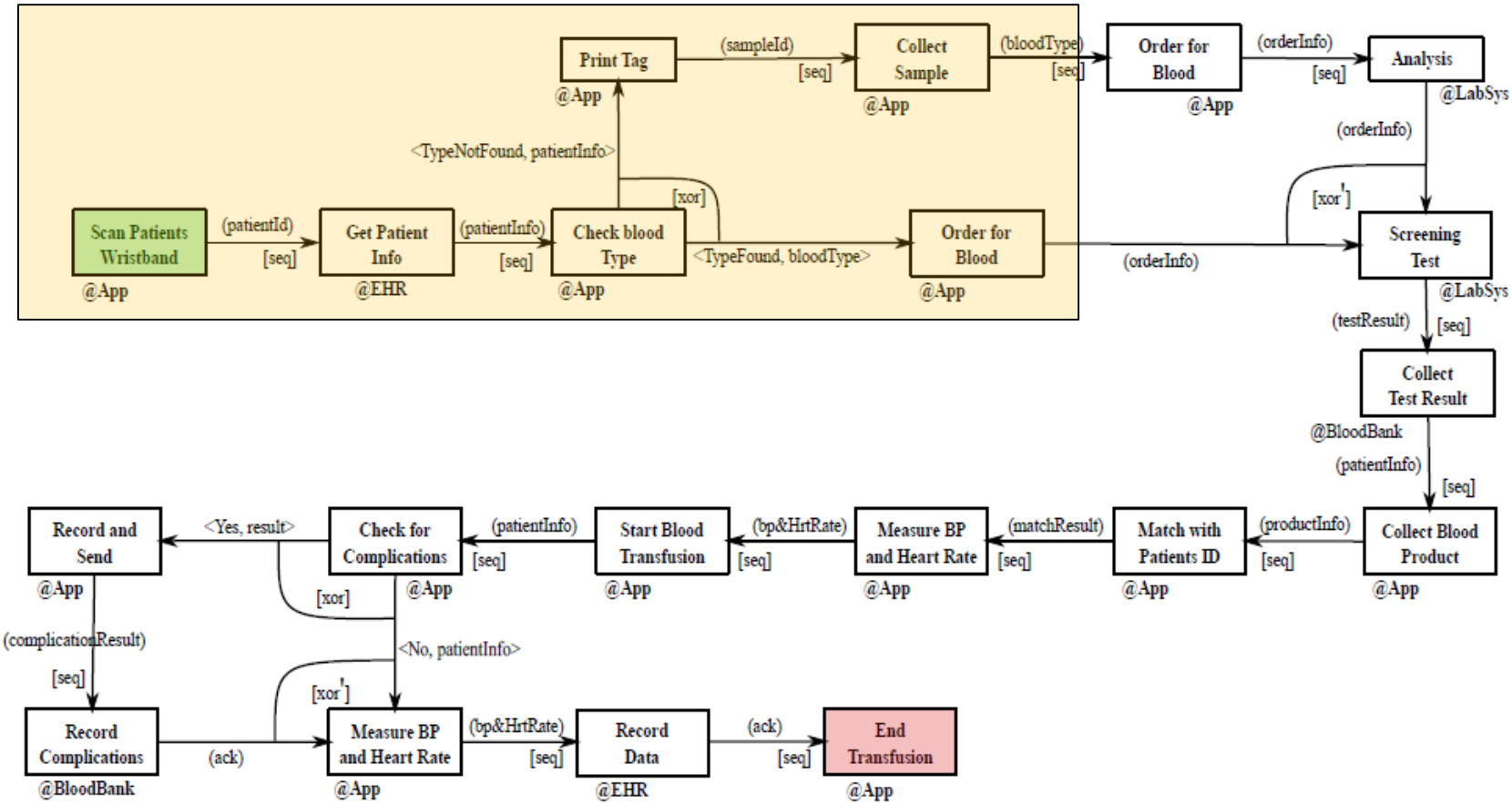
Web-based
[http://data2.hib.no:8080/dpf2.0/index.htm]

Overview: Multi Meta-modelling



Workflow Modelling

- **DERF language* extended with system locations, message passing, and condition predicates:**

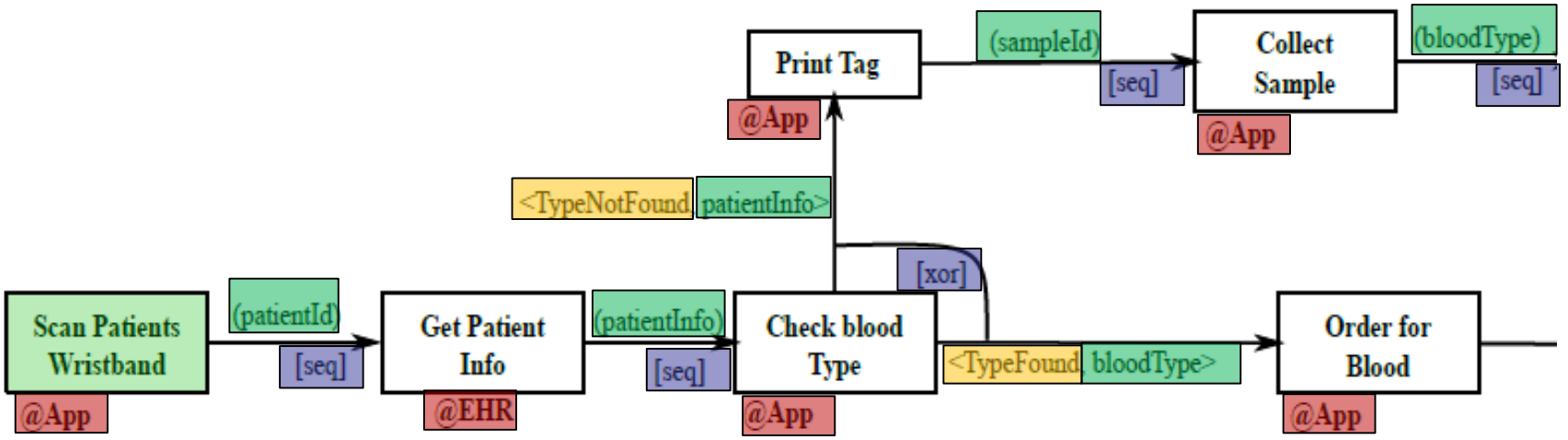


*A. Rutle, W. MacCaull, H. Wang, and Y. Lamo. A Meta-modelling Approach to Behavioural Modelling, In Proc . of BM-FA '12, pp. 5:1–10. ACM, 2012.

Workflow Modelling

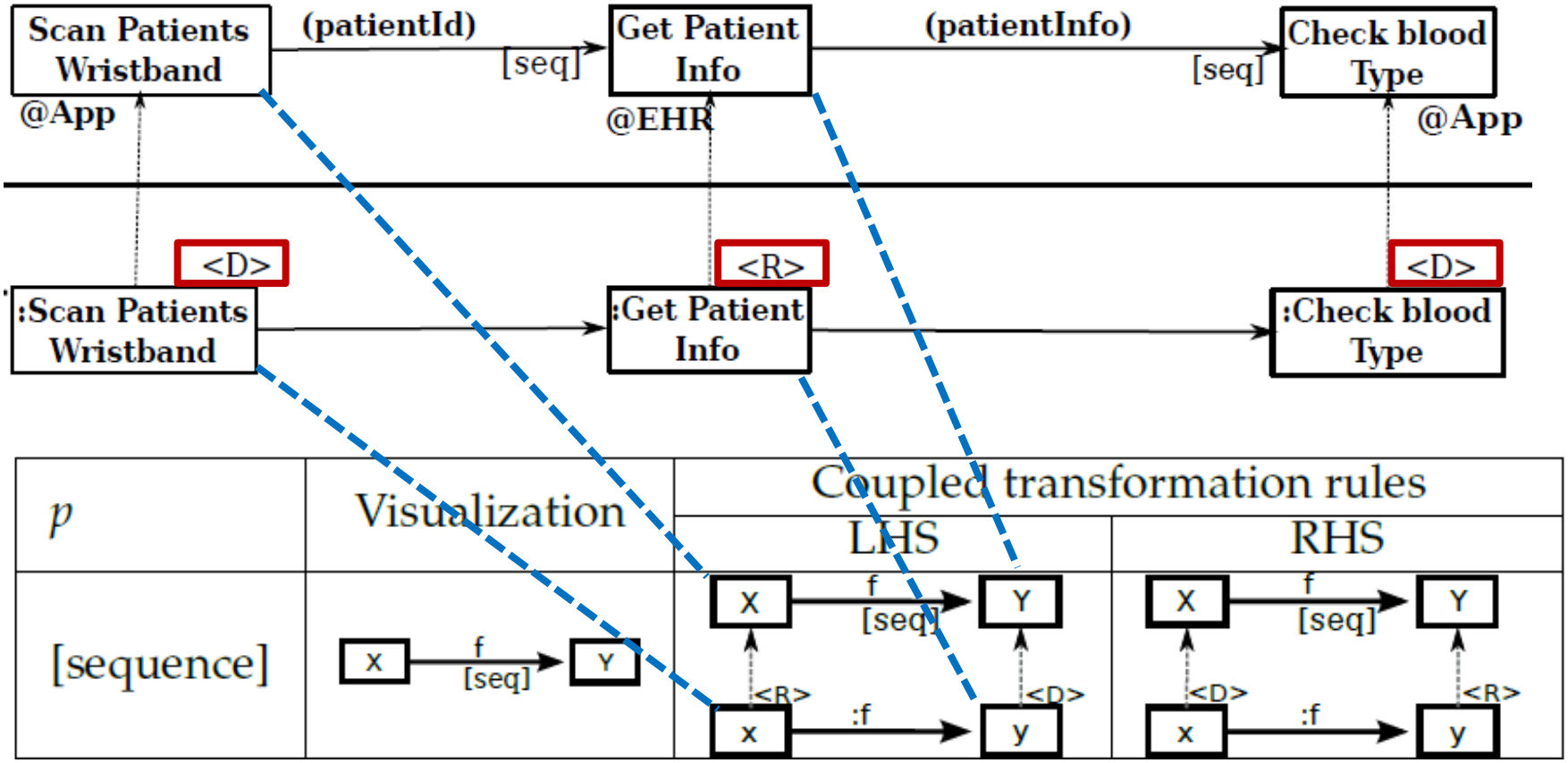
- **DERF language extended with system locations, message passing, and condition predicates:**

Workflow routing



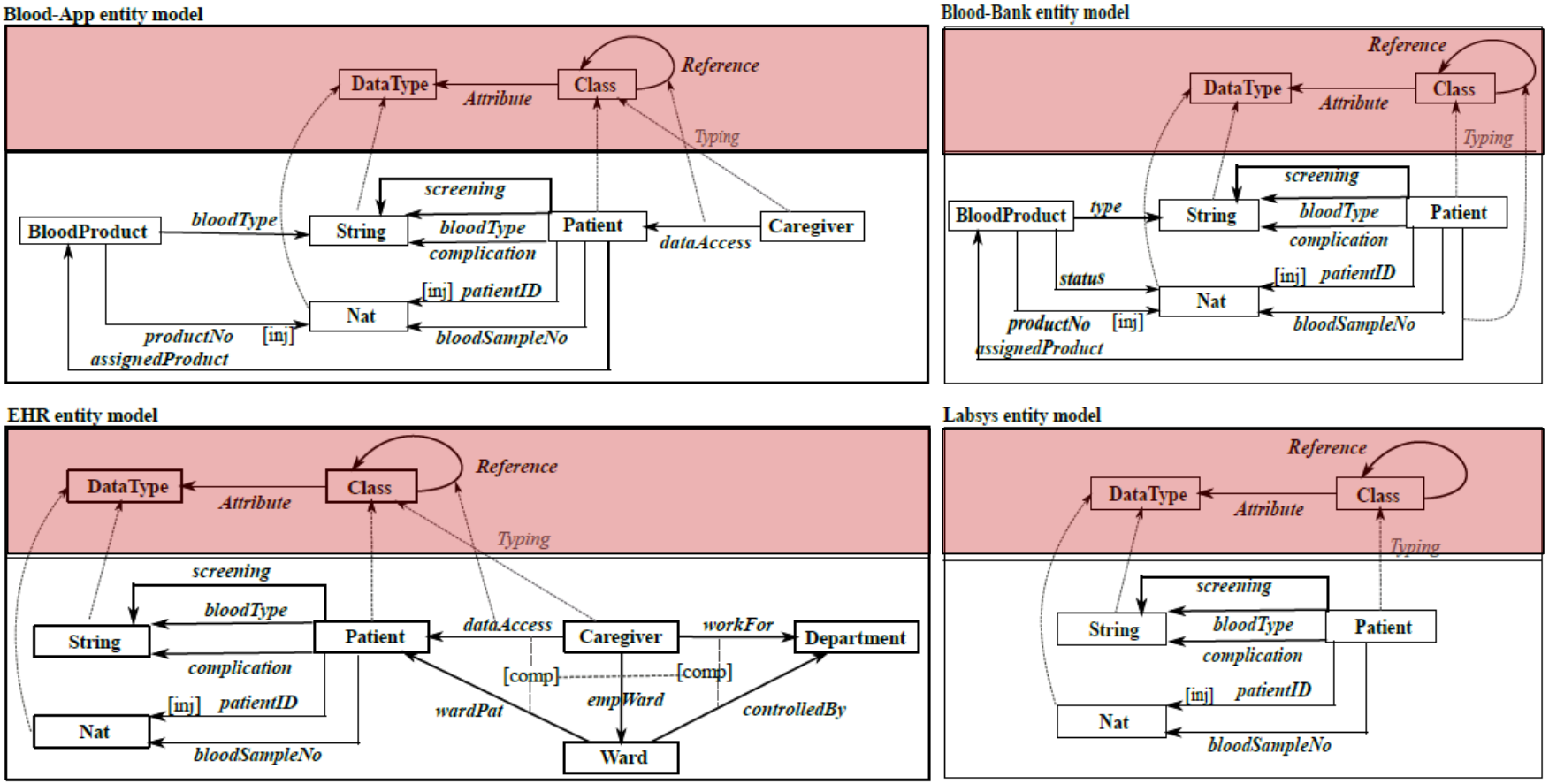
Workflow Execution

- **Execution of the extended DERF workflow models is based on model transformations:**



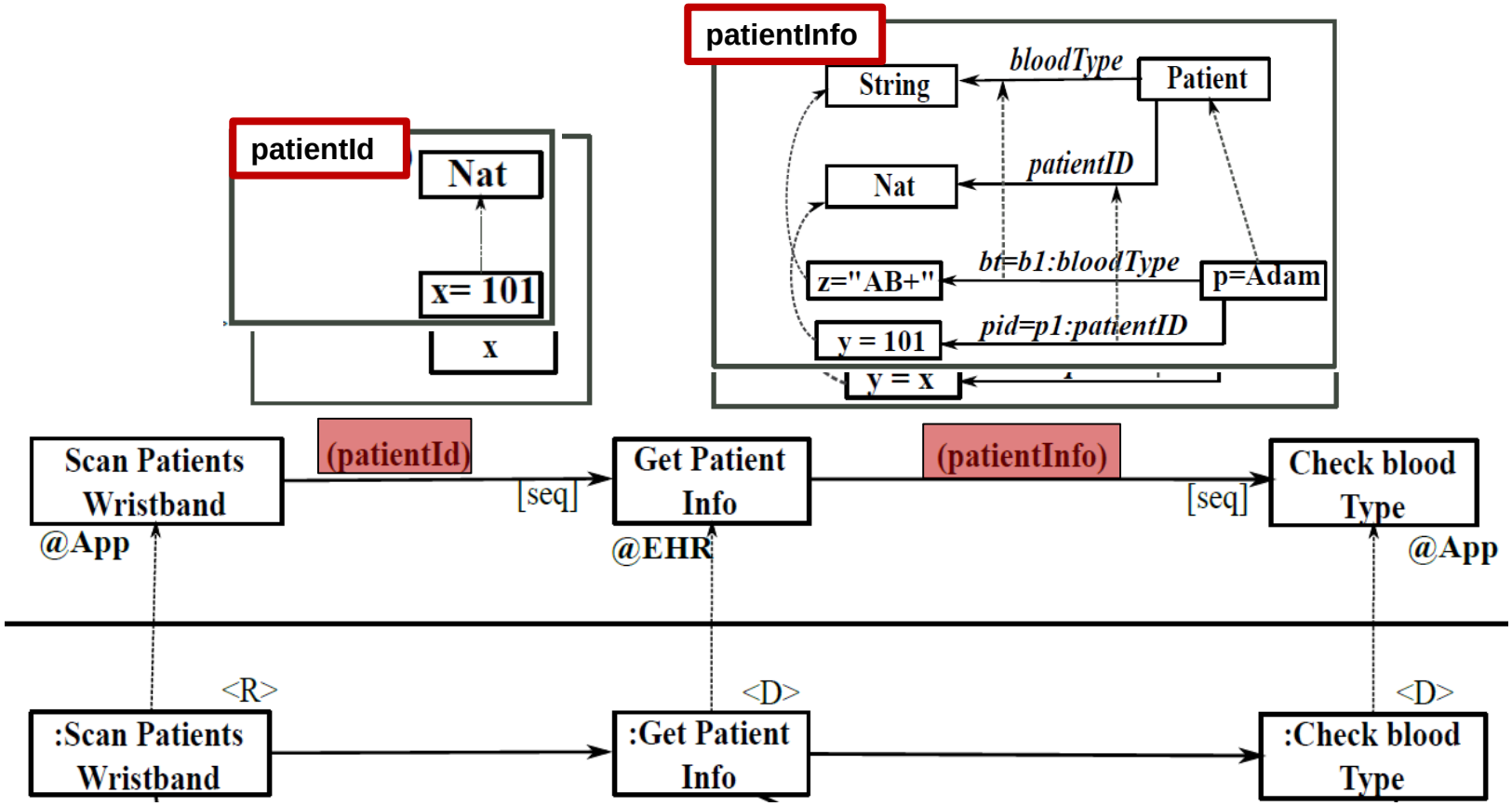
Entity Modelling

- **Subsystems may have different entity models - but rely on a common entity meta-model:**



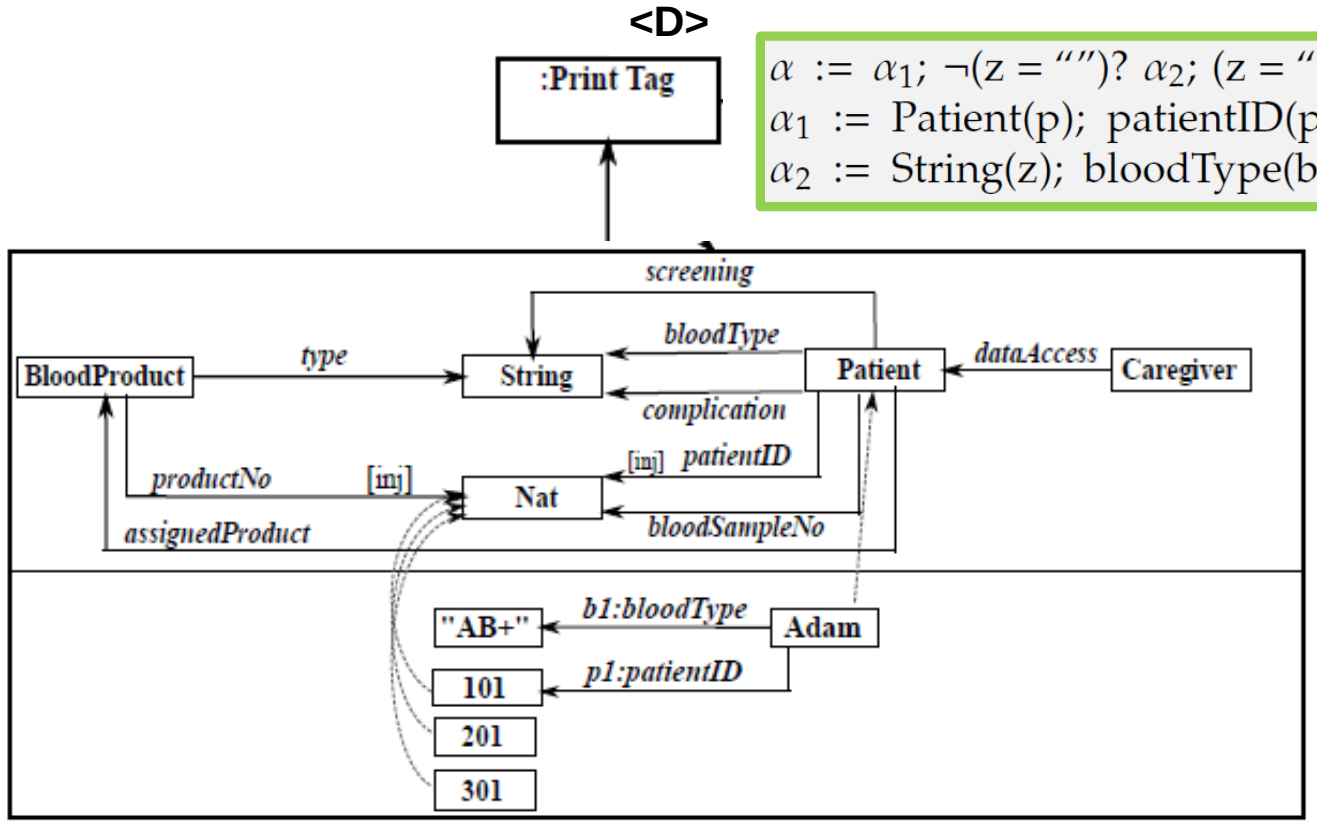
Message Passing

- **Based on typed graphs matched against subsystem entity instance models:**



Process Descriptions

- **Dynamic logic programs** are used to specify the detailed behaviour of processes.
- **Example -** Checking blood type:



$\alpha := \alpha_1; \neg(z = \text{“”})?\ \alpha_2; (z = \text{“”})?$
$\alpha_1 := \text{Patient}(p);\ \text{patientID}(pid);\ \text{src}(pid, p);\ \text{trg}(pid, y)$
$\alpha_2 := \text{String}(z);\ \text{bloodType}(bt);\ \text{src}(bt, p);\ \text{trg}(bt, z)$

```
y   = 101
p   = "Adam"
z   = "AB+"
pid = p1
bt  = b1
```

Conclusions and Future Work

- **A multi-modelling approach for the development of distributed healthcare applications:**
  - Workflow modelling and workflow execution.
  - Entity modelling and process descriptions.
  - Message passing and process locations.
- **Evaluation on a blood transfusion application.**
- **Ongoing and future work:**
  - Modelling language extensions: exception handling, timing constraints, modules and containments (abstraction).
  - Simulation-based validation of the application design: process conformance and user experience.
  - Formal verification: workflows and process descriptions.
  - Code generation: interfaces for the application subsystems.