Joint ITU-T and SDL Forum Society workshop on
„ITU System Design Languages“
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Model-based development of self-organized earthquake early warning systems

Joachim Fischer

Klaus Ahrens, Ingmar Eveslage, Frank Kühnlenz

SAFER = Seismic eArly warning For EuRope

Outline

- Fast trip through the
  - nature of earthquakes
  - seismological analysis
- Prototyping and administrating infrastructure for EEWS
  - modeling languages SDL, UML, ASN.1
  - tool chain
    as an adoption and extension of PragmaDev DS
  - geographical context relation
- First use cases of SOSEWIN: *EEWS prototype Istanbul*
- Conclusions

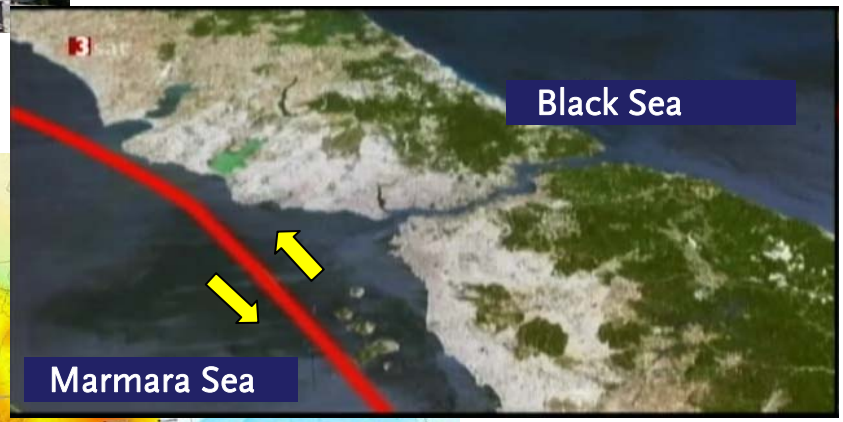
Danger for Mega-City Istanbul

SAFER
Seismic eArly warning For EuRope

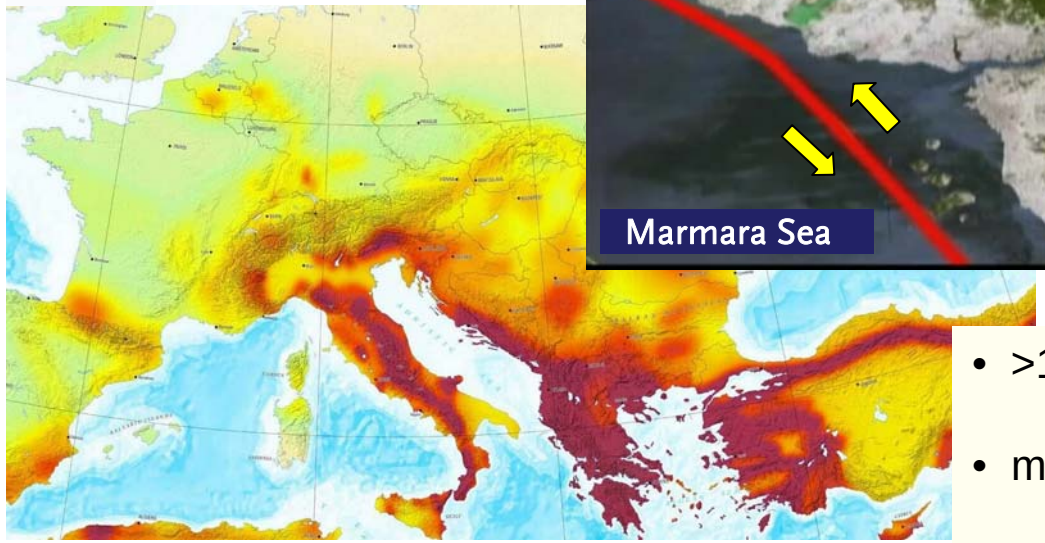
Task 4.4

Sebastian Heglmeier, Björn Lichtblau,
Jens Nachtigal, Jens-Peter Redlich,
Kevin Fleming, Claus Milkereit,
Matteo Picozzi, Ingo Veit,
Klaus Ahrens, Ingmar Eveslage,
Joachim Fischer, Frank Kühnlenz

- Egypt
- France
- Germany
- Greece
- Island
- Italy
- Norway
- Romania
- Switzerland
- Turkey



GFZ
POTSDAM



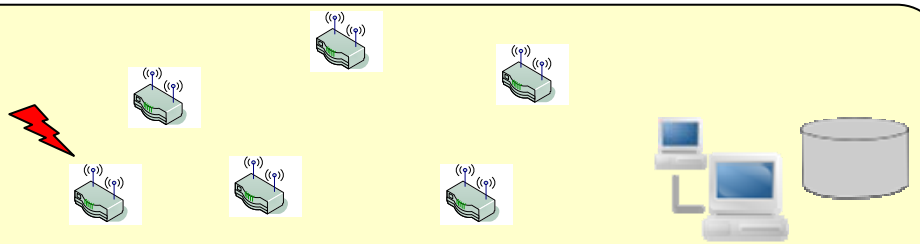
earthquake risk map

- >14 Mio. inhabitants,
  yearly addition of 250.000
- many buildings
  were smutty and illegal established
- 50% of Turkish economic output

Current Seismometer Networks

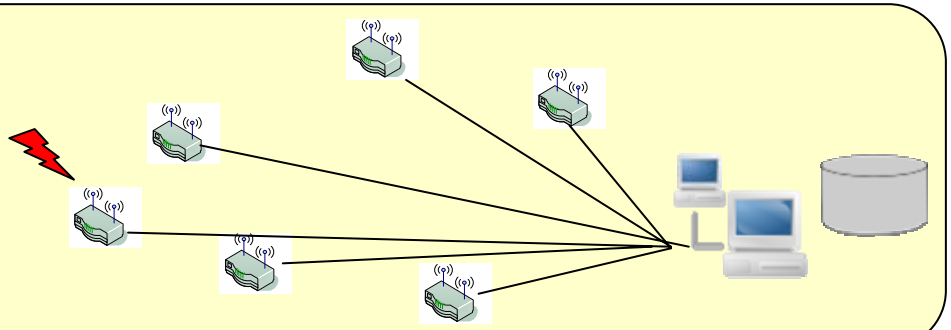
isolated

- high-cost sensitive seismometers (5.000 – 20.000 € / node)
- far away of living areas



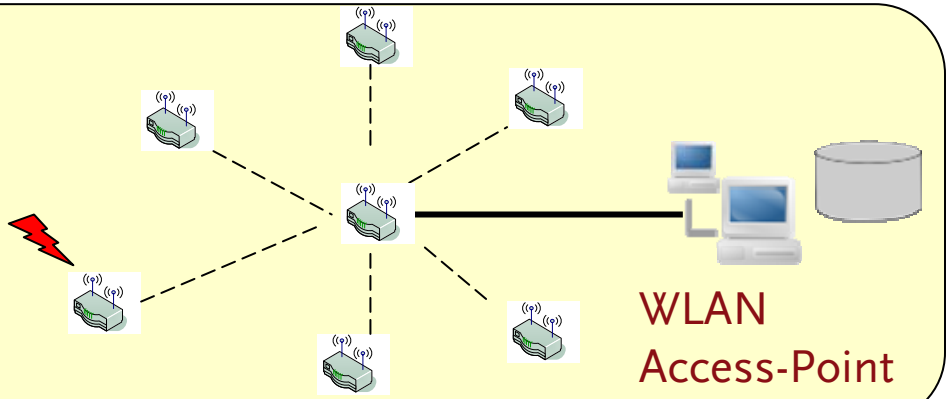
wired connected

- high-cost sensitive seismometers
- far away of living areas

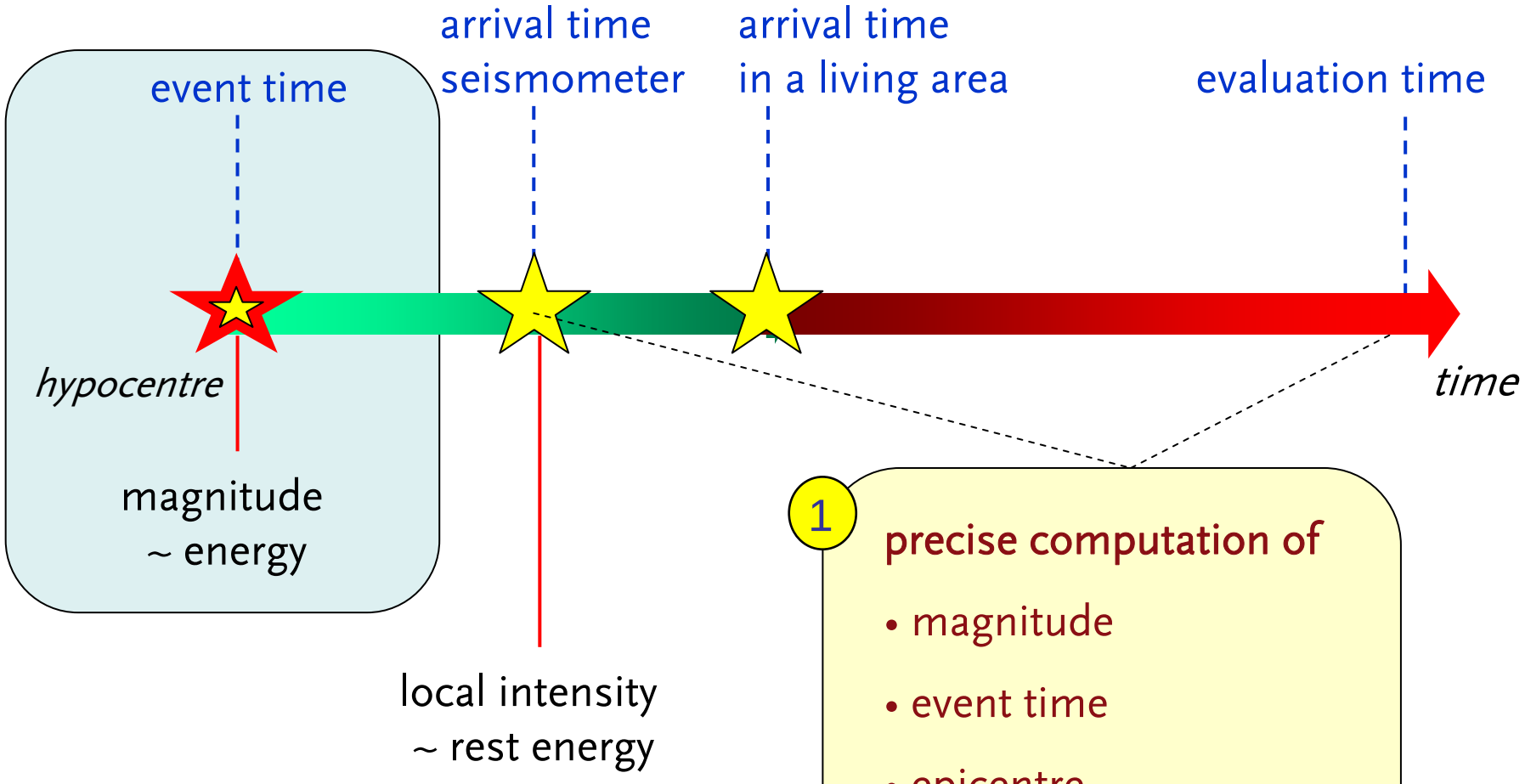


wire-less connected

- centralized management
- high-cost sensitive seismometers
- directed antennas
- far away of living areas



Various Goals of Seismometer Networks



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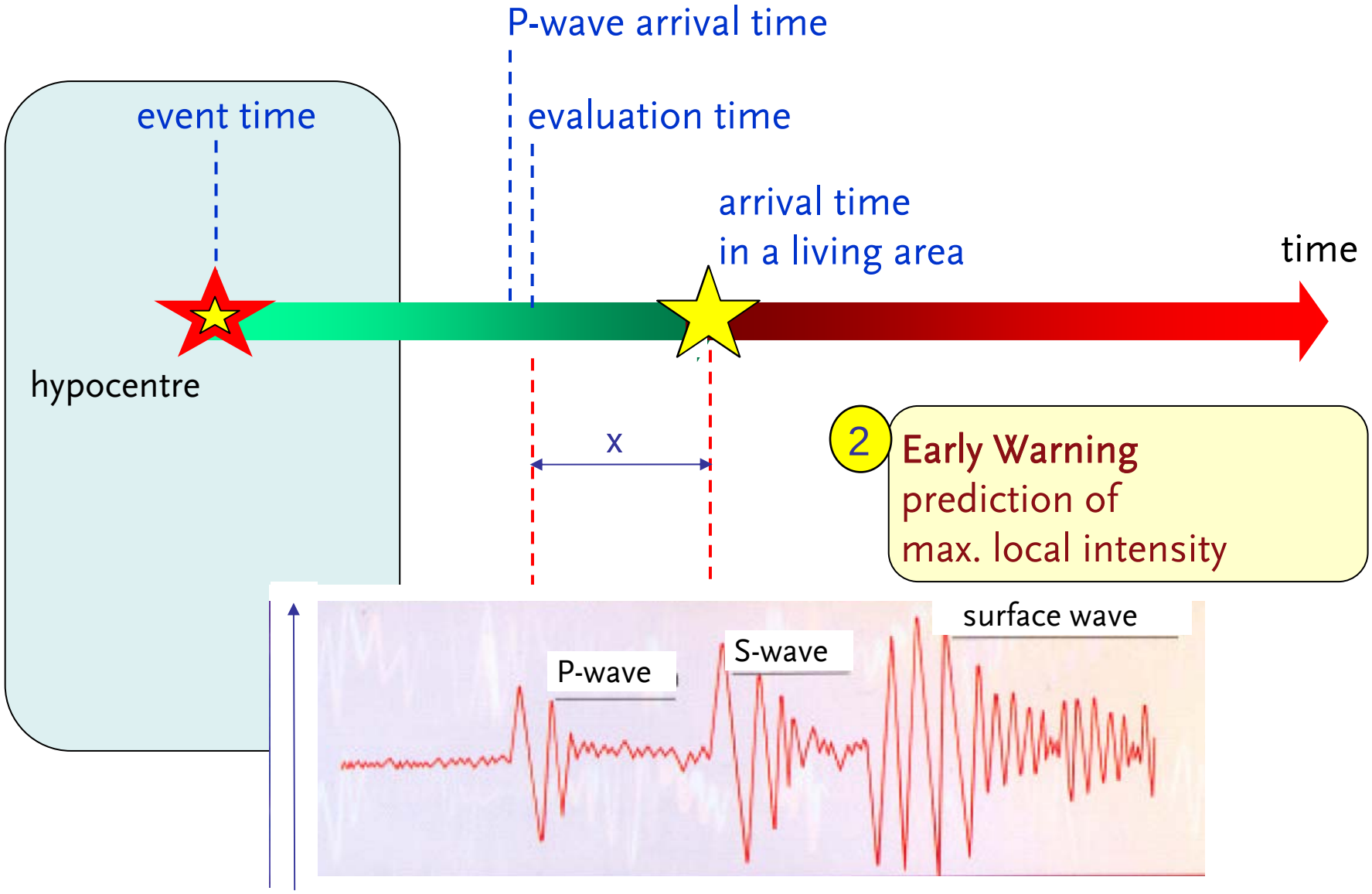
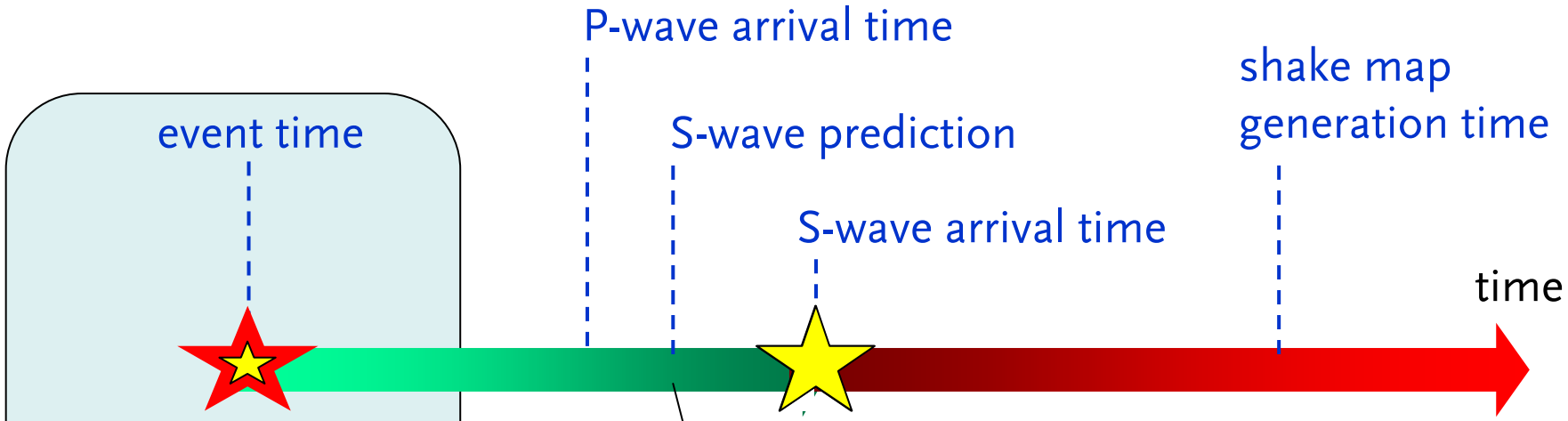
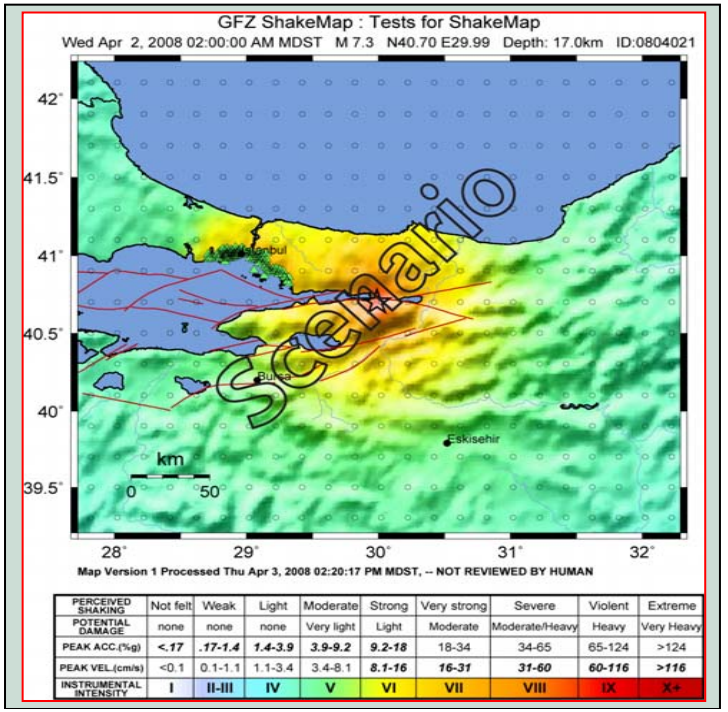


Various Goals of Seismometer Networks



3 **Rapid Response**
online shake maps
...

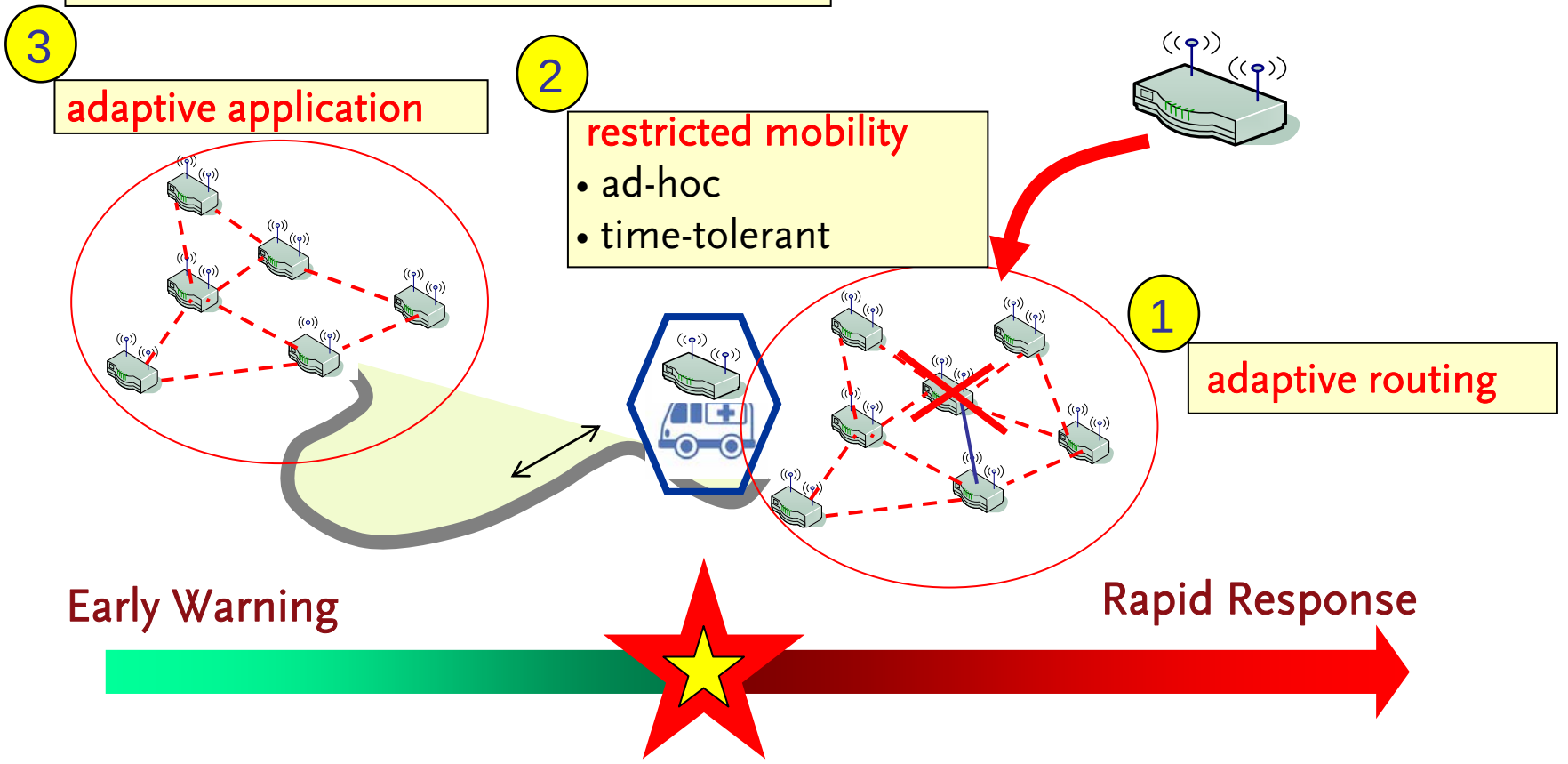


Our Approach: Paradigm of Self-Organisation

network characteristics
- low-cost seismometer (300 € / node)
- wire-less
- meshed, multi-hop
- decentralized management

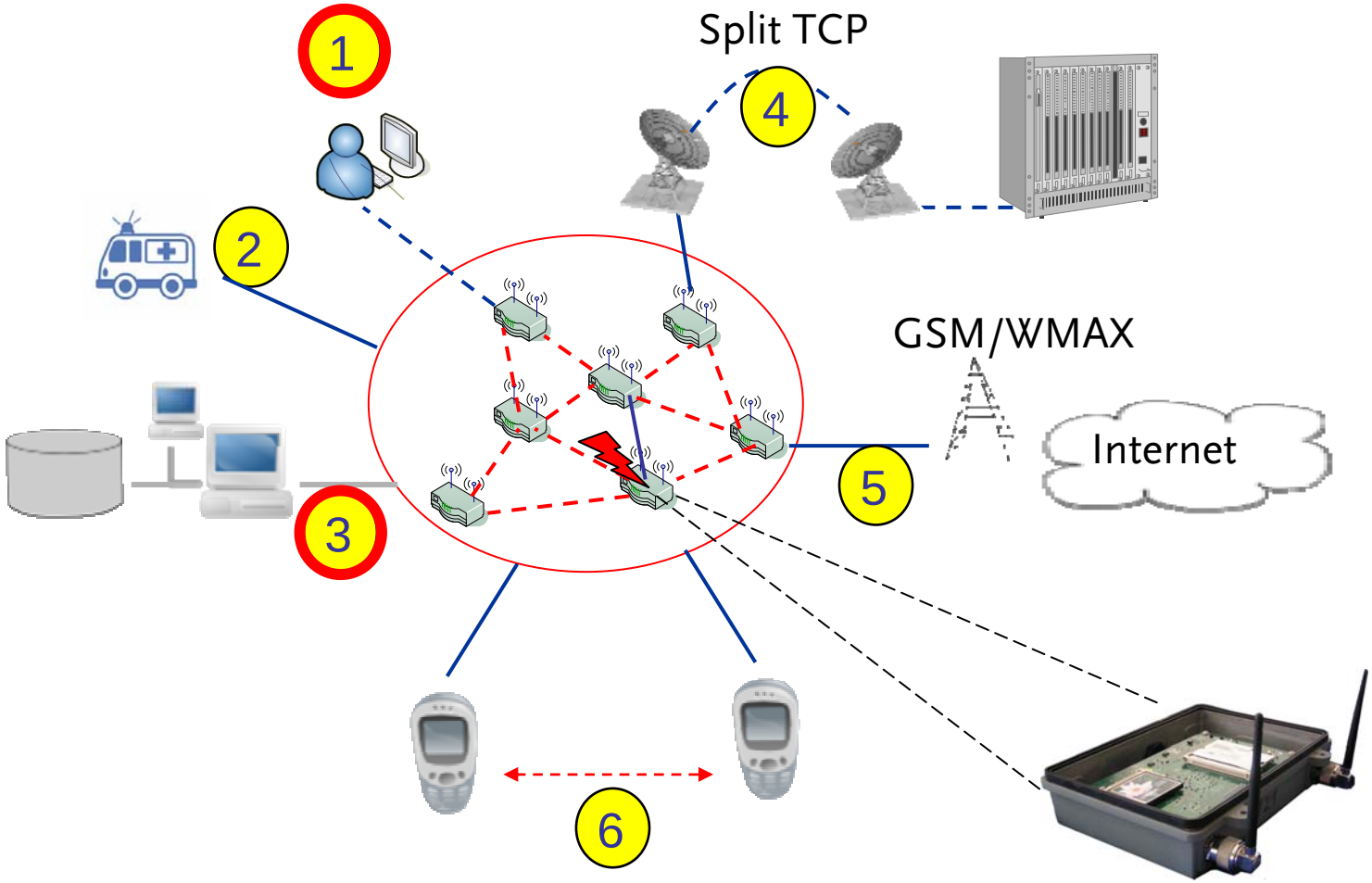
+

- high density
- directly in living areas !!!

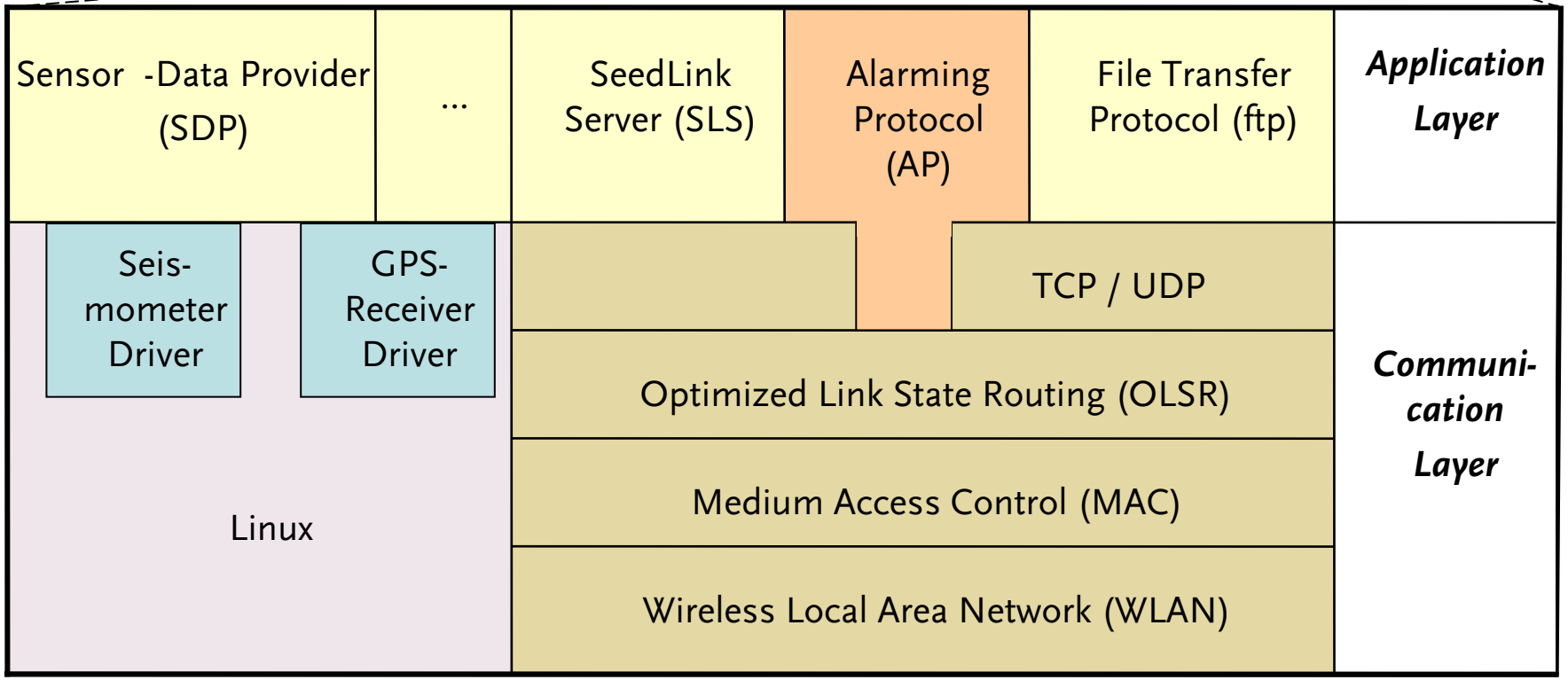


System Integration

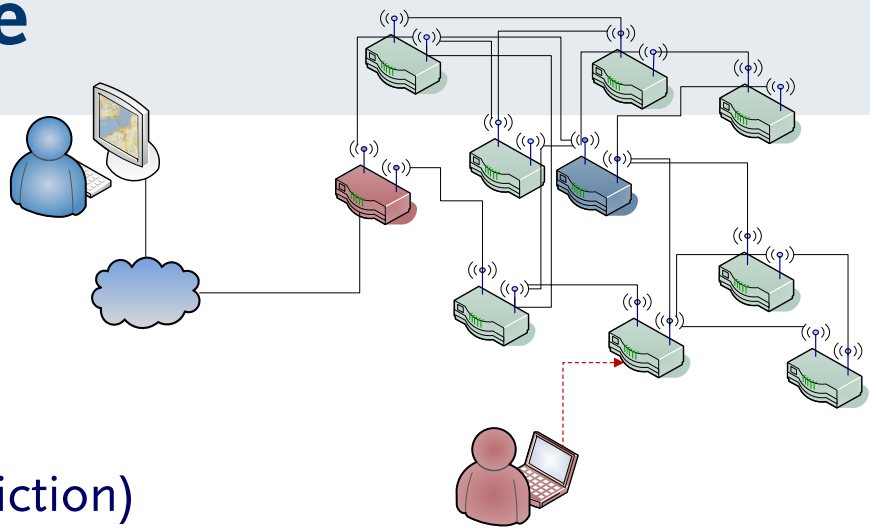
... with existing infrastructures



SOSEWIN – Software Architecture



Alarm Protocol Principle



three-level alarming procedure
for avoiding fault alarms

(1) **Single node alarm**
(P-wave recognition, S-wave prediction)
→ only the corresponding group leader node is informed immediately

(2) **Group alarm**
(a critical number of group members are in Signal-Node Alarm Status)
→ (all) other group leaders are informed immediately

(3) **System alarm**
(a critical number of group leader nodes are in Group Alarm Status)
→ all gateway nodes are informed immediately

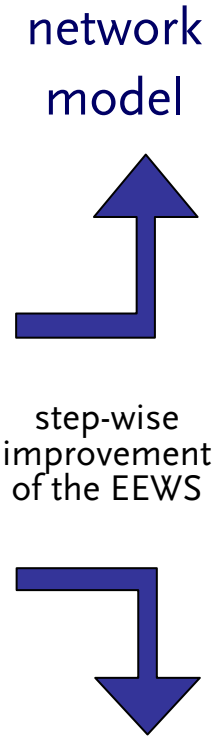
Model-based EEWS Prototyping & Administrating Infrastructure

... should support

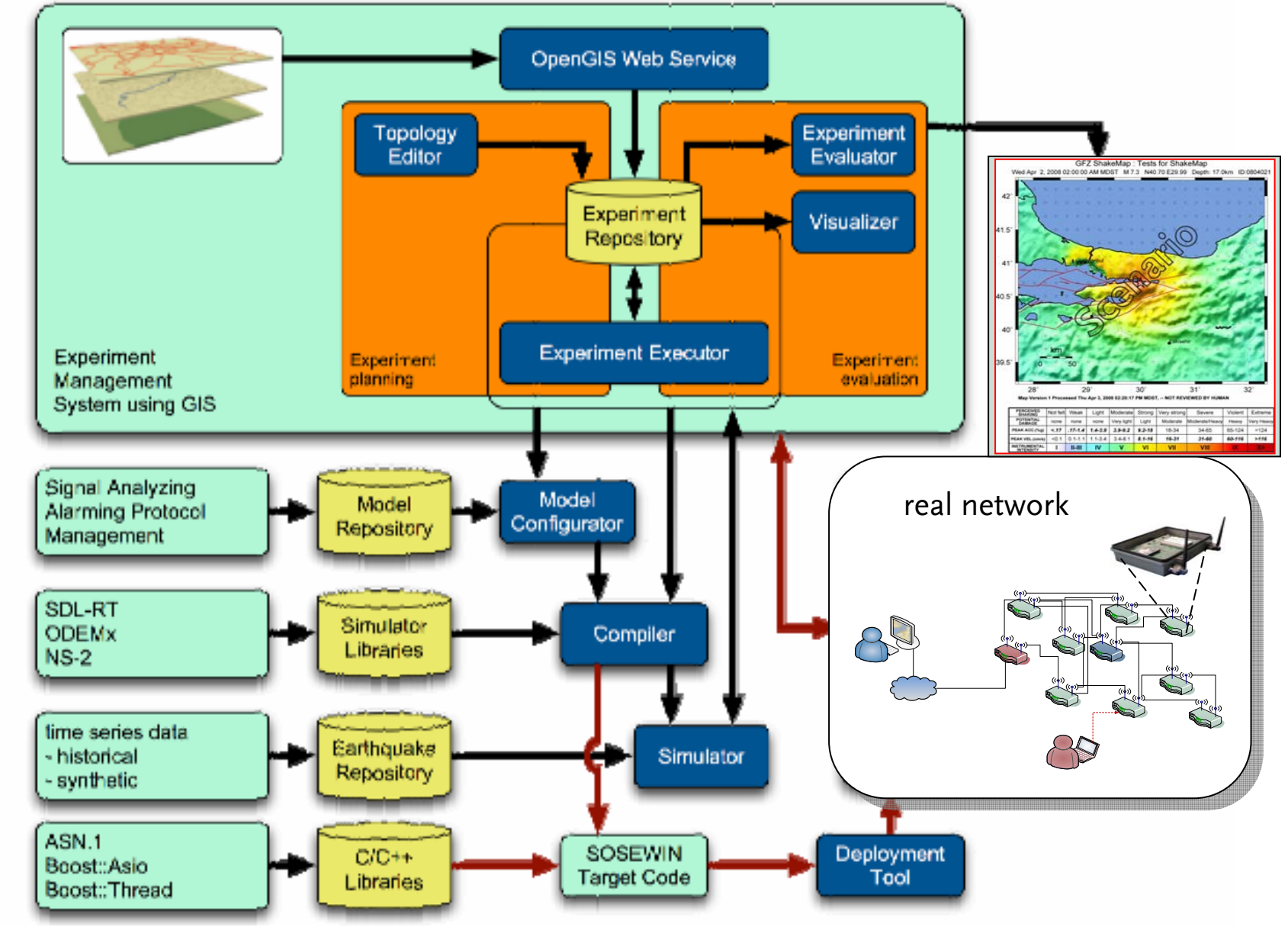
1. **model development of**
   - software components for
     - seismic signal-analyzing
     - protocol software offering cooperative alarming and
     - other domain-specific distributed services
   - GIS-based earthquake input data streams (synthesizer, time series)

2. **generation of simulators to test network models**
   - GIS-based network configuration
   - observation and evaluation of the network *under different artificial earthquake scenarios*

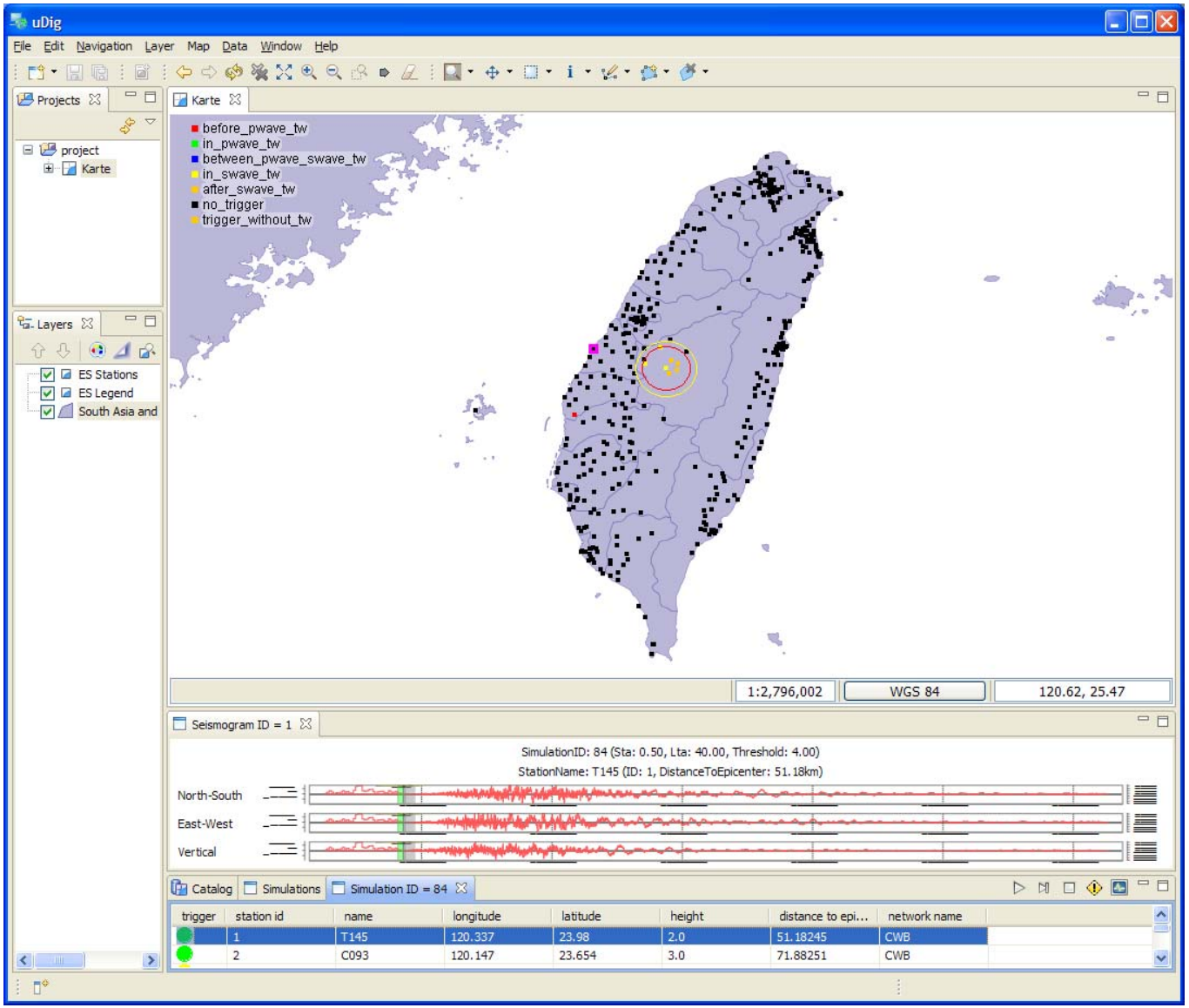
3. **generation and usage of target code from improved network models**
   - GIS-based system installation
   - monitoring, evaluation and administrating of the network *under different artificial **and** real earthquake scenarios*
   - maintenance



Model-based EEWS Prototyping & Administrating Infrastructure

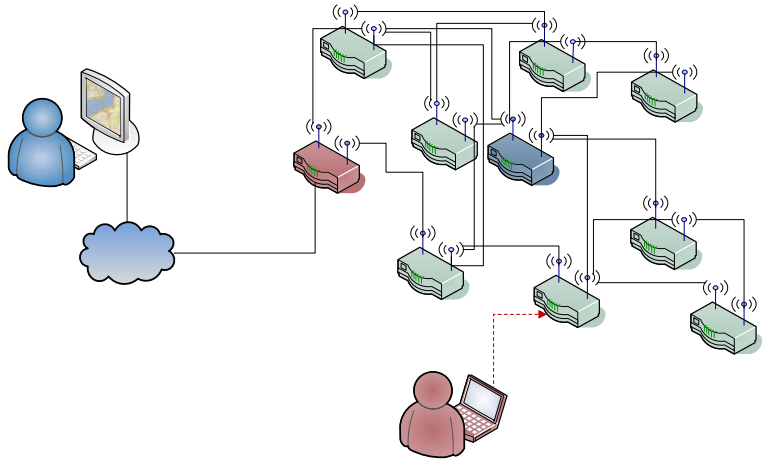


Network Topology Editor



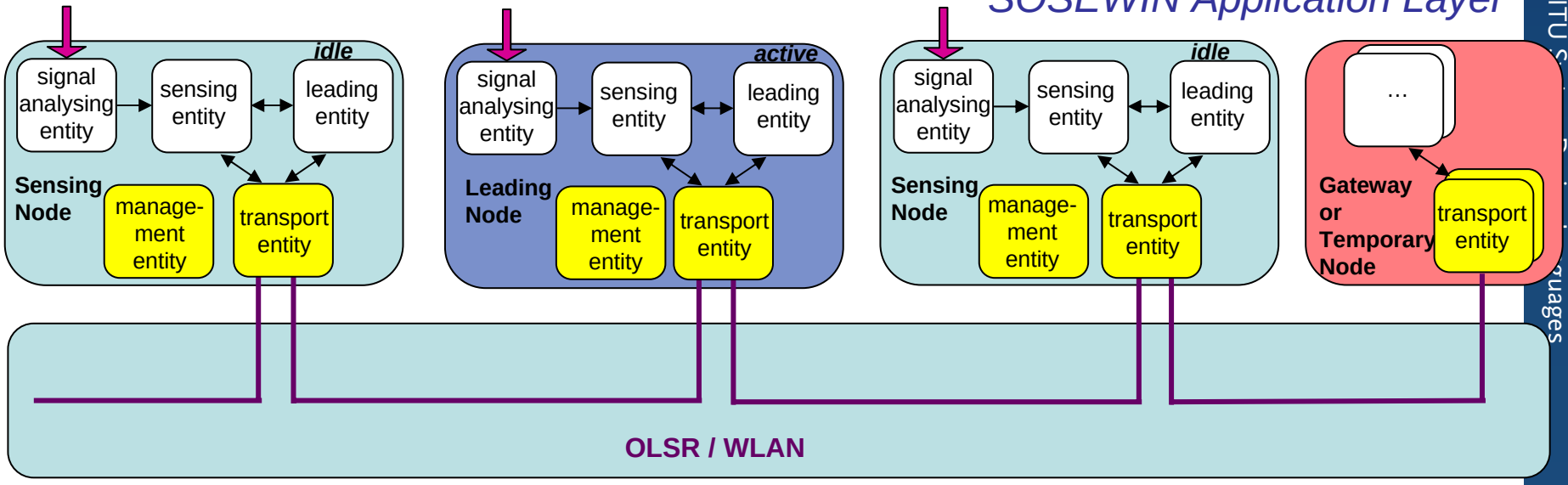
SOSEWIN Nodes and Alarm Protocol Entities

- sensing nodes
- routing nodes
- leading nodes
- temporary nodes
- gateway nodes
- external nodes



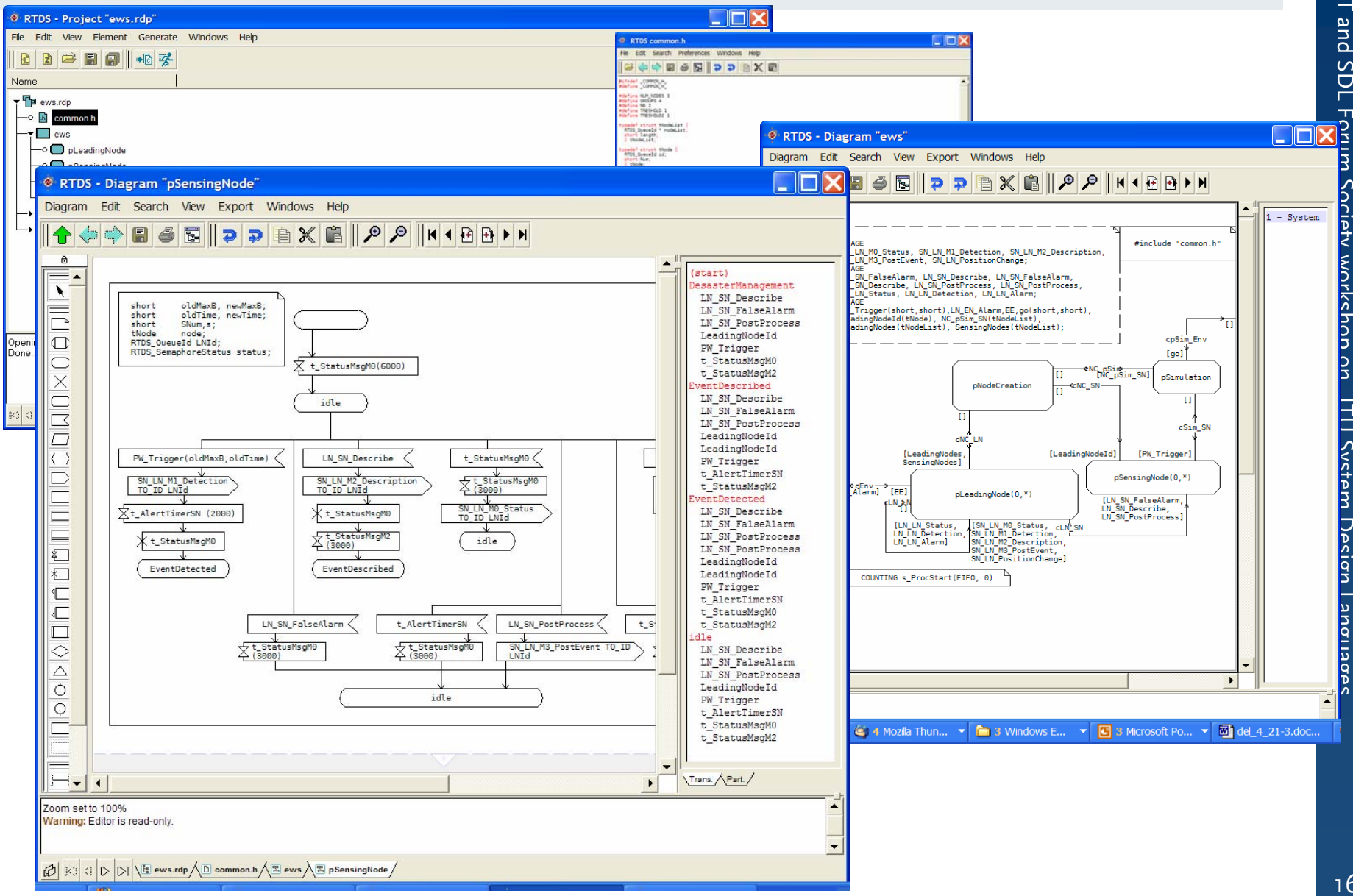
input stream of accelerometric raw data

SOSEWIN Application Layer

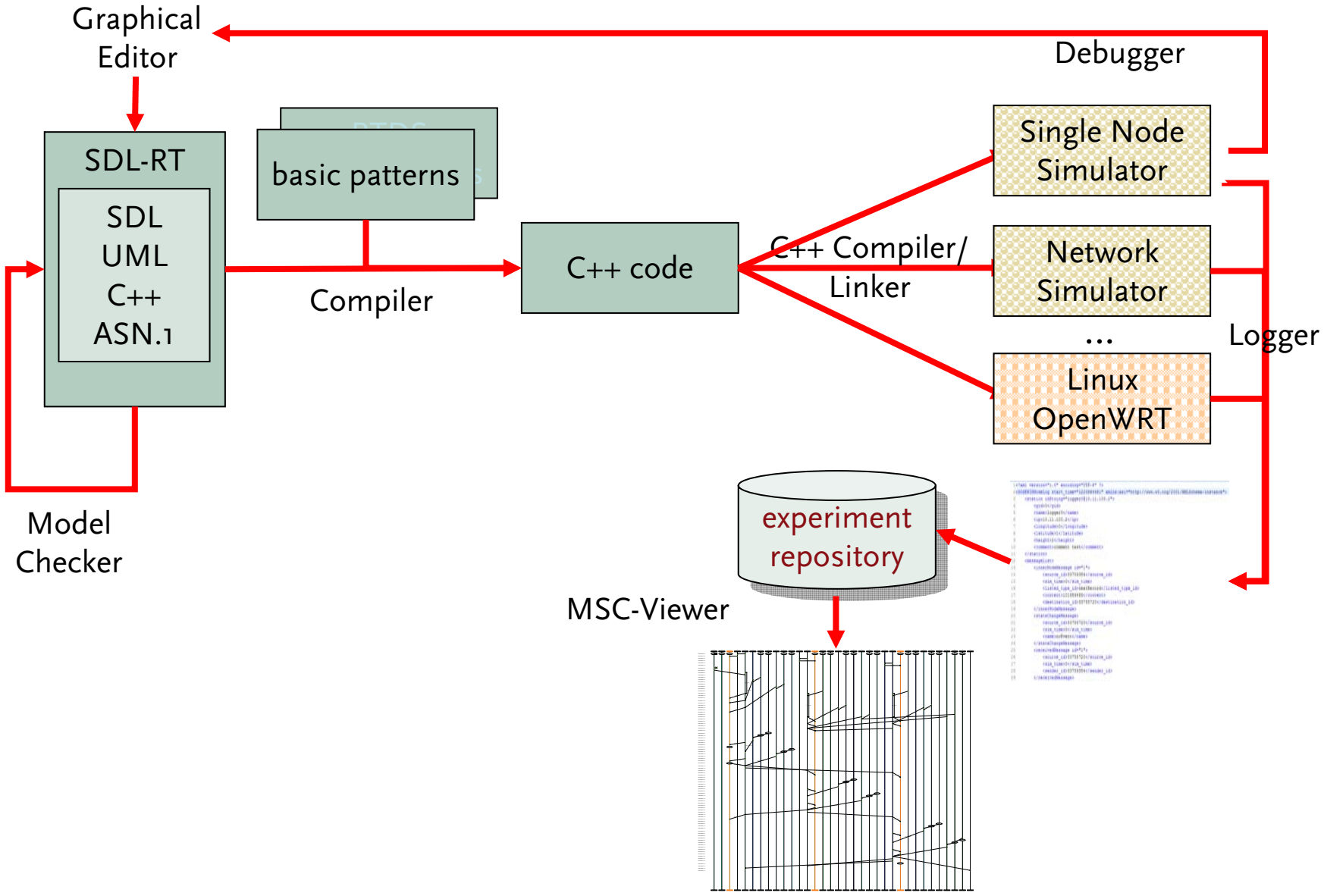


SOSEWIN Communication Layer

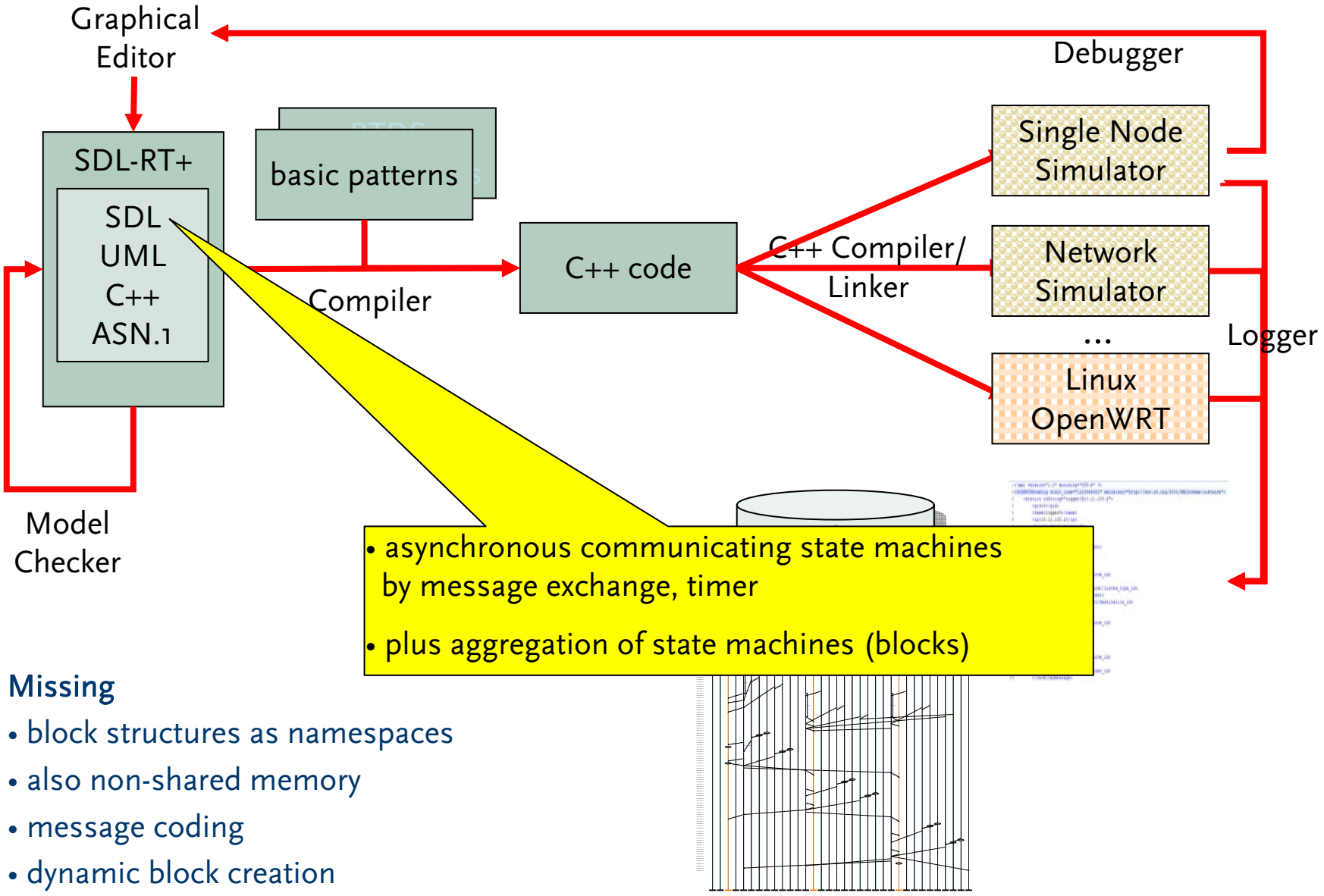
SDL-RT Development of Alarm Protocol Entities



SDL-RT Tool Chain: From Models to Code



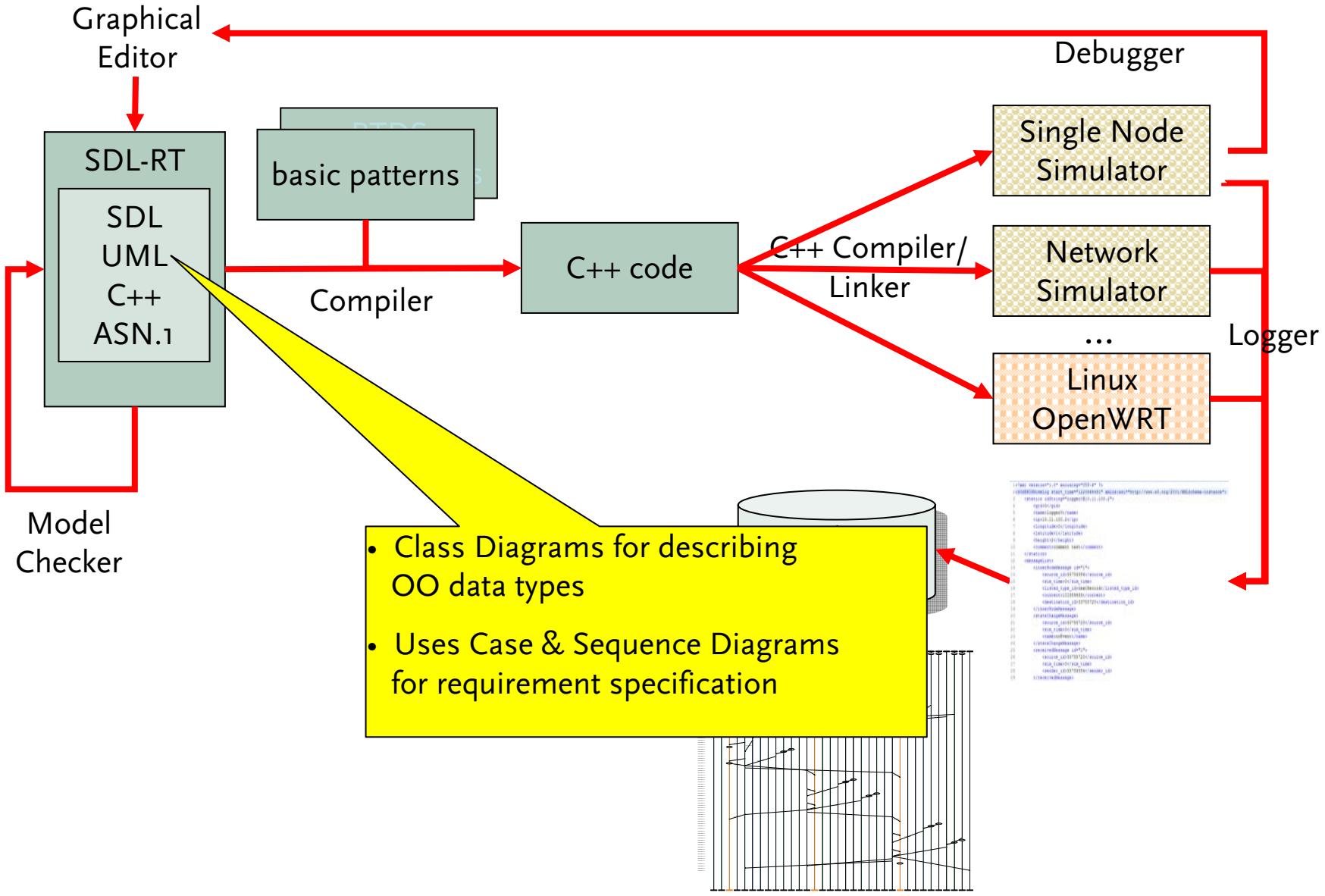
SDL-RT Tool Chain: From Models to Code



Missing

- block structures as namespaces
- also non-shared memory
- message coding
- dynamic block creation

SDL-RT Tool Chain: From Models to Code



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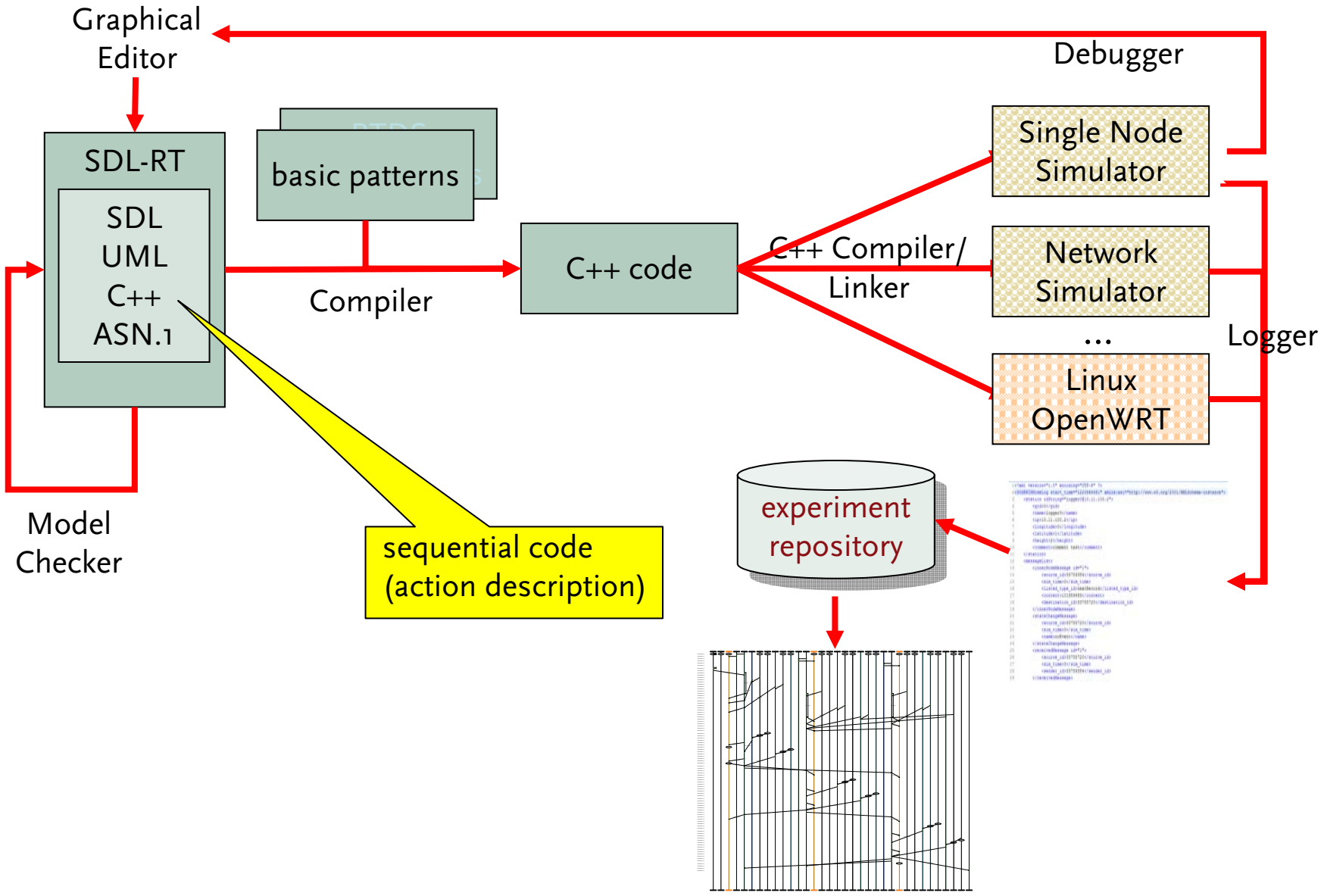
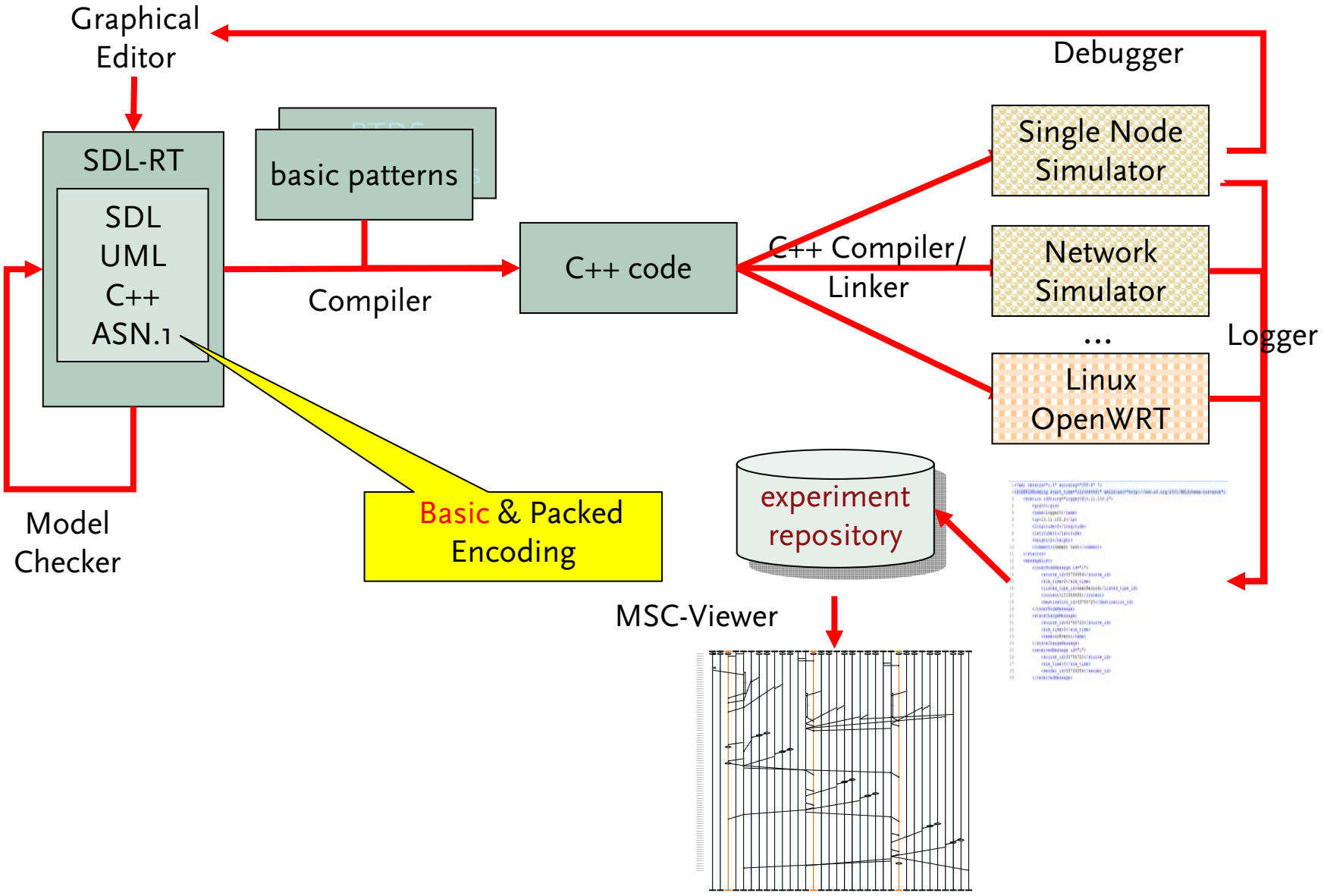
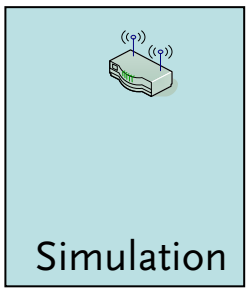


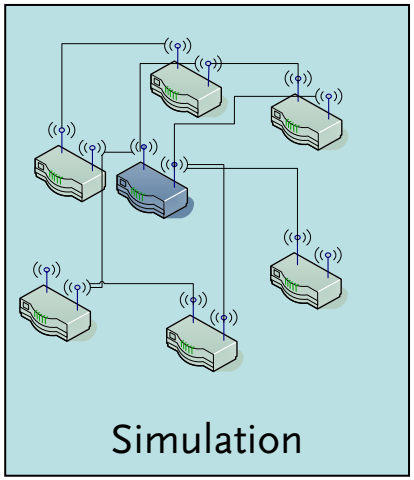
SDL-RT Tool Chain: From Models to Code



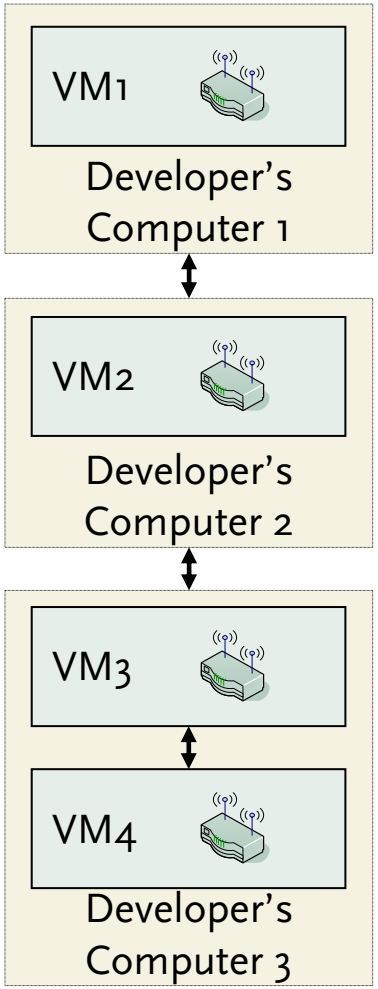
Different Experiment Set-Ups for Testing



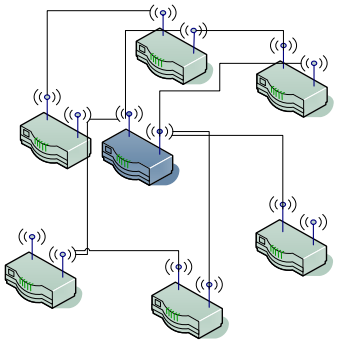
Set-Up 1:
Developers Computer



Set-Up 2:
Developer's Computer

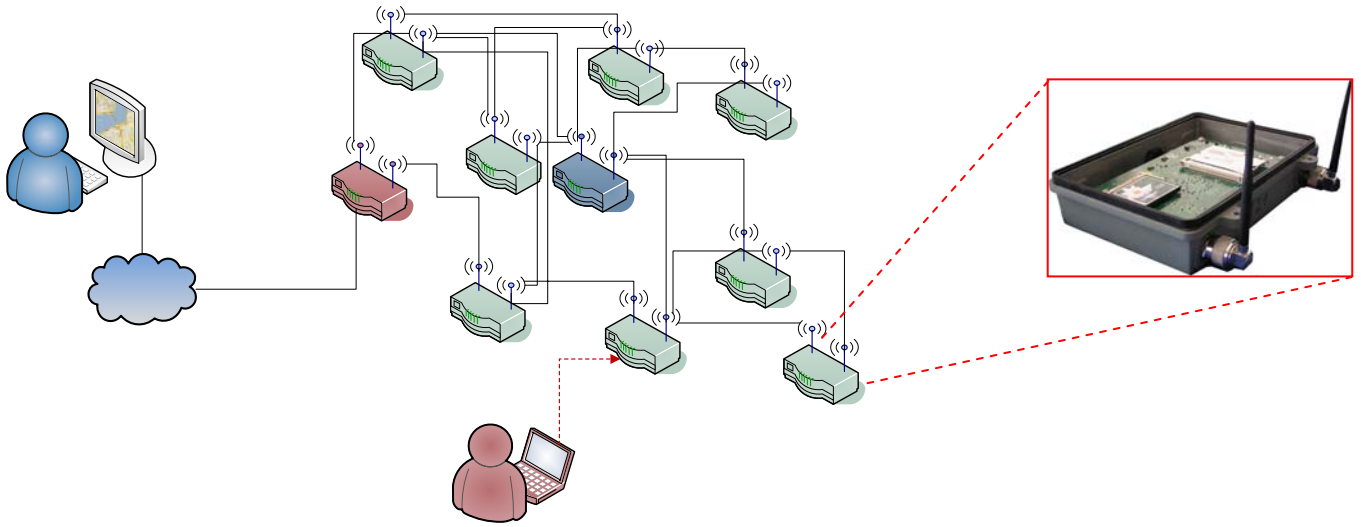


Set-Up 3:
Set of Virtual Machines



Set-Up 4:
Real World

First Use Case: SOSEWIN Prototype in Atakoy



First Recognized Earthquake Event

GFZ Potsdam - Earthquake Bulletin

Region: **Turkey**

Time: **2008-07-10 07:50:00.6 UTC**

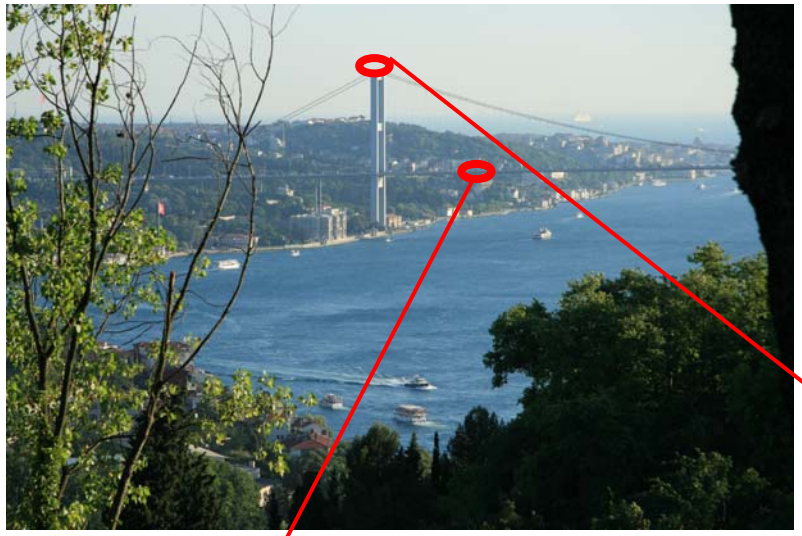
Magnitude: **4.7**

Epicentre: **27.77°E 39.91°N**

Depth: **20 km**

Distance from Atakoi: **160 km**

Second Temporary Use Case: Fatih-Sultan-Mehmet Bridge



total length 1.510 m

breadth 39,4 m

hight 64 m

opening 1988

Summary, Conclusions

- a first version
  of a prototyping and administrating infrastructure
  for self-organized EEWS and rapid response systems

- SDL-RT with only few extensions is a powerful DSL for EEWS specifications

- SOSEWIN as a first use case in Istanbul

  plan for automated deployment of
  the alarming protocol at the SOSEWIN-network in Atakoi
  generated from tested SDL-RT+ specifications

- more tests for further improvements of
  - the infrastructure
  - of real-time and robustness characteristics of SOSEWIN

- establishment of a consortia for a commercial EEWS product development