Projekt Erdbebenfrühwarnung
im WiSe 2010/11

Entwicklung verteilter echtzeitfähiger Sensorsysteme

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1. Einführung

1. Experimentelle Basis: SOSEWIN-Prototyp
2. Etwas zu Erdbeben und Frühwarnung
3. Unser Konzept einer Erdbebenfrühwarnung
4. Unser modelbasieter Entwicklungsansatz
5. Aktuelle SOSEWIN-Einsatzfälle

SOSEWIN- Prototyp

Self-organizing Seismic Early Warning Information Network

HU Berlin

GIS

GIS

Ataköy Istanbul

Internet

GFZ Potsdam

Kandilli Istanbul

GIS

Istanbul-Infrastruktur-daten

Interdisziplinäre Projekte

- Graduiertenkolleg METRIK
- EU-Projekt SAFER
- BMBF-Projekt EDIM im Rahmen von Geotechnologien
- Start eines weiteren BMBF-Projektes zur kommerziellen Produktion verbesserter SOSEWIN-Knoten

+ Studentisches Projekt in 3. Generation

GFZ Helmholtz-Zentrum Potsdam

Jochen Zschau

Kandilli Observatory and Earthquake Research Institute

Istanbul

Mustafa Erdik

SAFER Seismic eArly warning For EuRope

Erstinstallation von SOSEWIN

Istanbul, Mai 2008

mit Sensorik, aber ohne Alarmierungssoftware

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Erdbeben
(Epizentrum, Hypozentrum, lokale Magnitude, Richterskala),

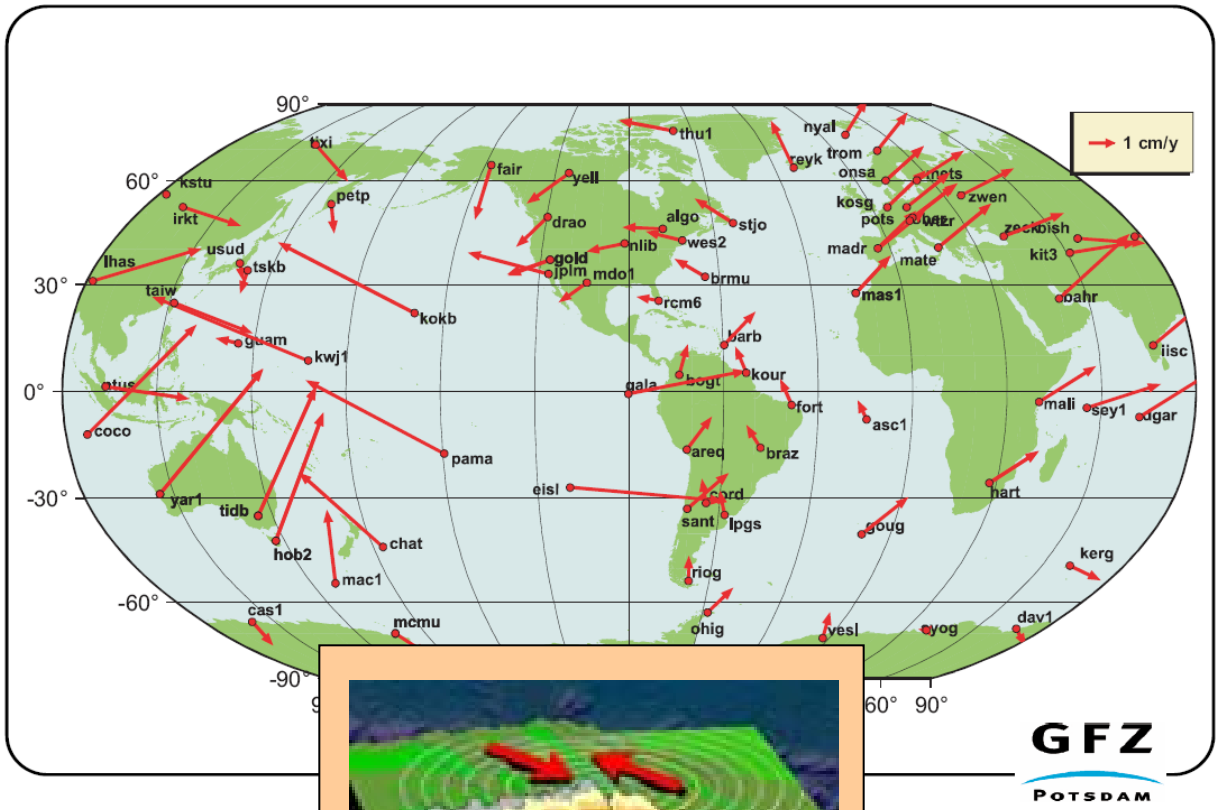
Seismische Wellen
(Wellentypen),

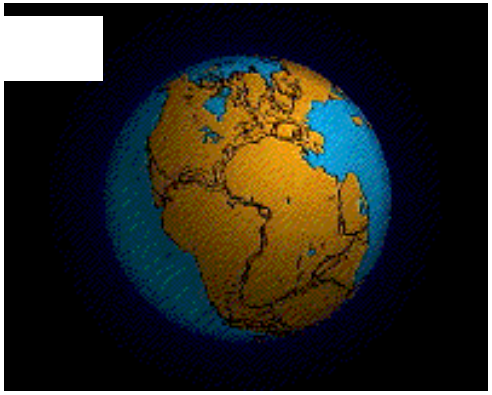
Seismometer
(Seismogramme),

Seismologische Herausforderungen
(Frühwarnung, Rapid Response)

The Natural Cause of Earthquakes

displacement vectors GPS data from 7 years





lithosphere

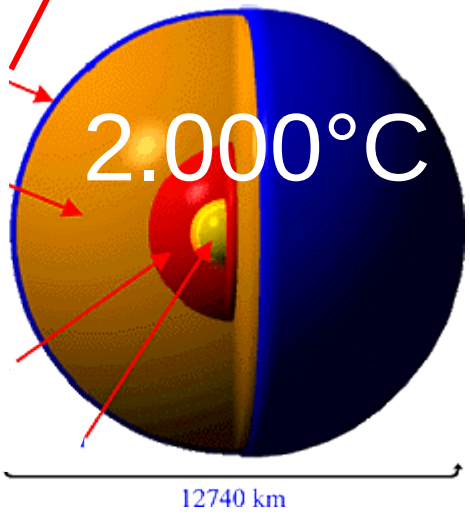
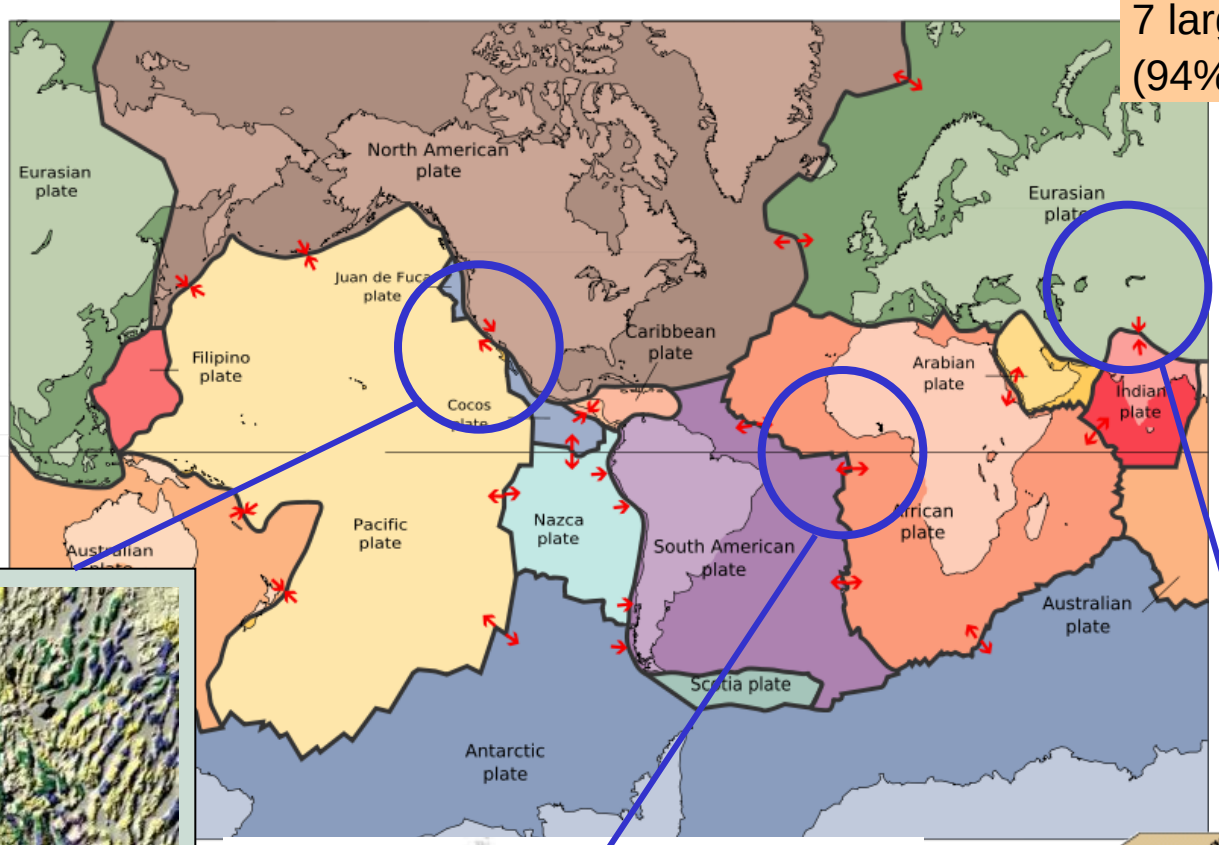
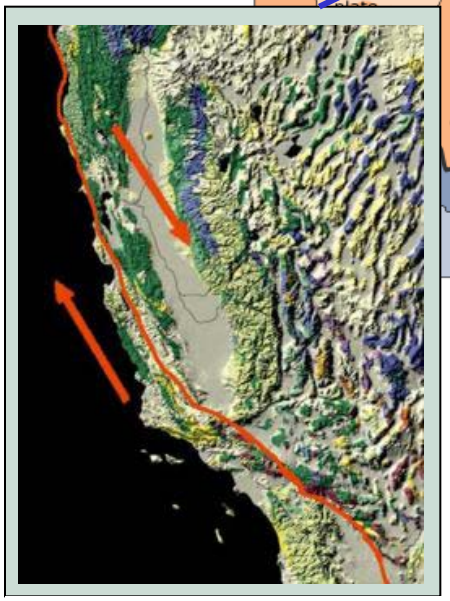


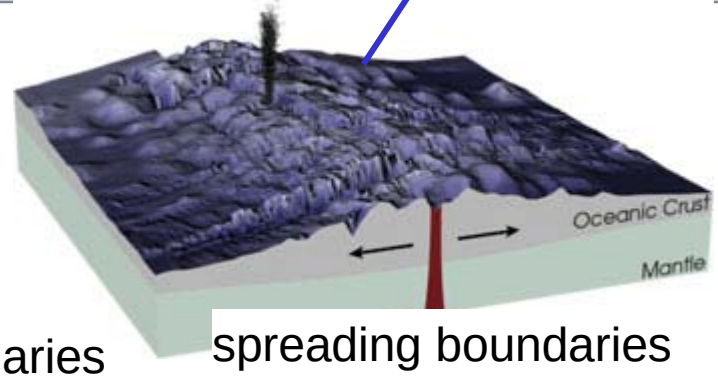
Plate Tectonics, Fault Types

7 large plates
(94% of the surface)

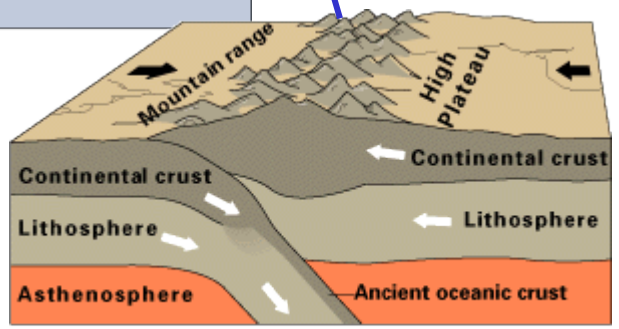




transformation boundaries

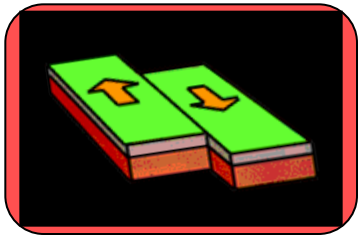


spreading boundaries



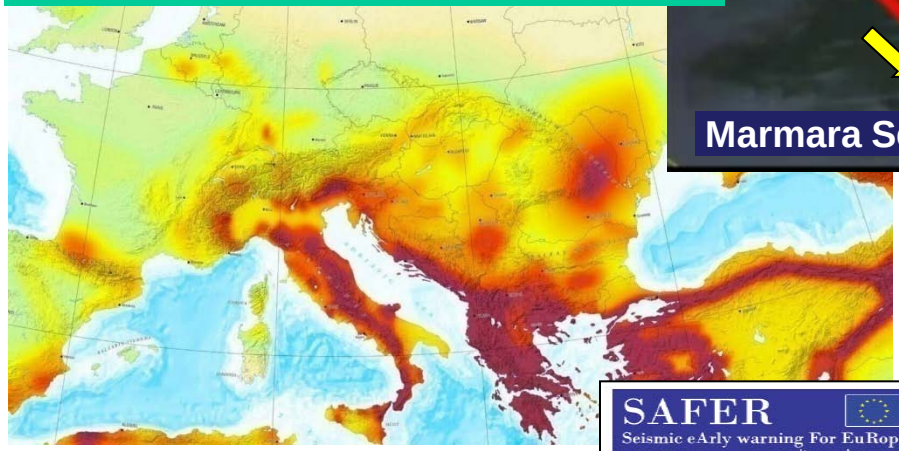
collision boundaries

Bedrohung der Mega-City Istanbul



- >14 Mio Einwohner, jährlicher Zuwachs 250.000
- viele Gebäude wurden schlampig und illegal errichtet
- 50% der türkischen Wirtschaftsleistung

17.08.1999, Stärke7.8



Risikokarte

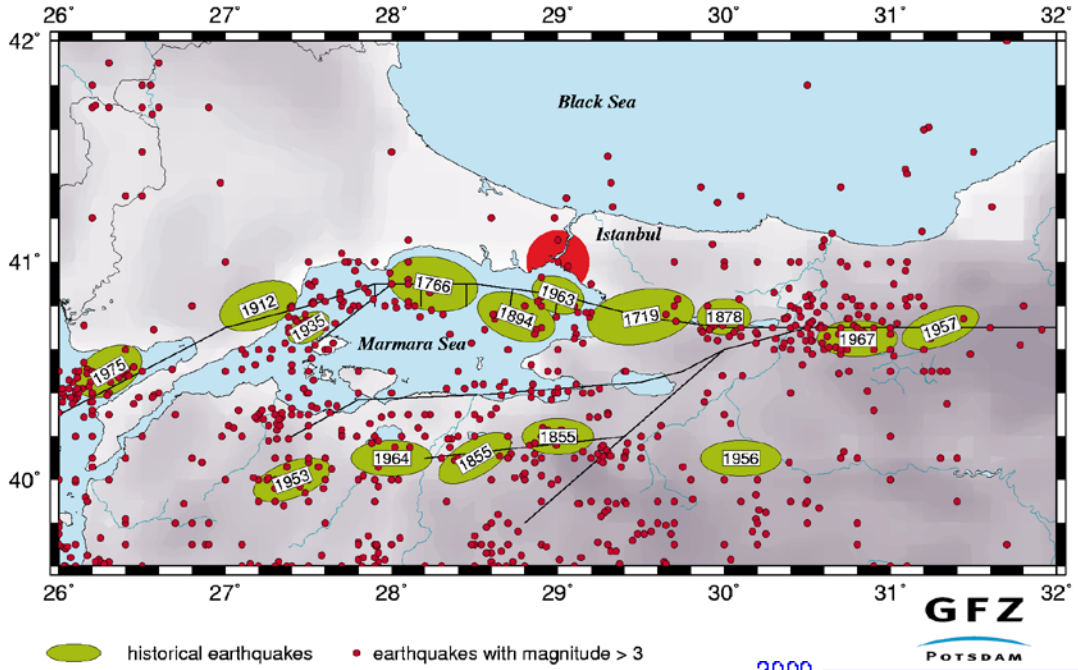
SAFER
Seismic eArly warning For EuRope

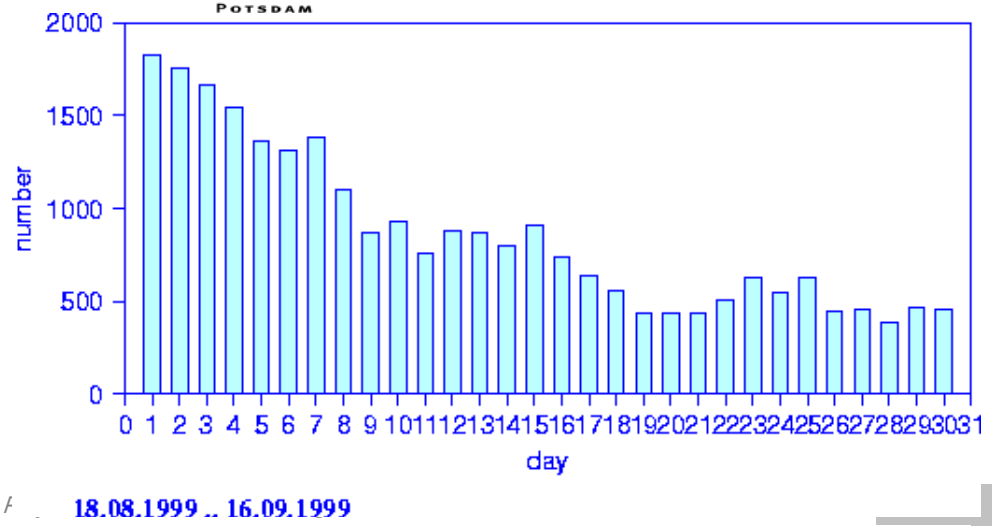
Systemanalyse J.Fischer

warnung

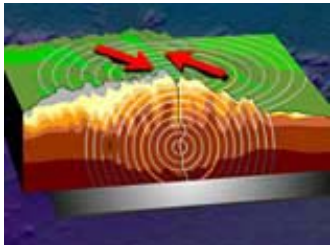
E. Günther

Plate Tectonics in Turkey

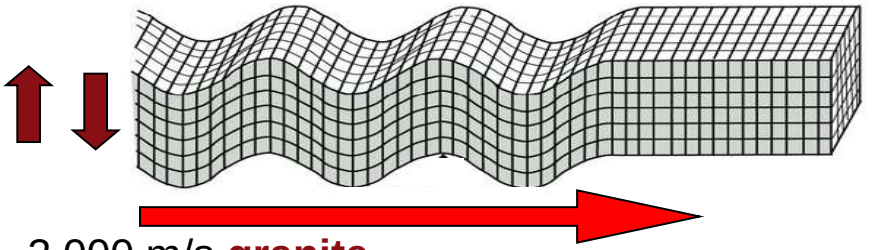




Wave Types

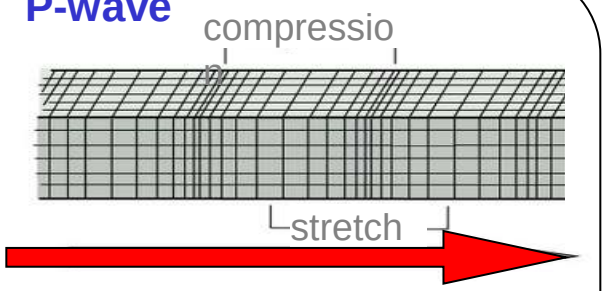


S-wave



3.000 m/s **granite**

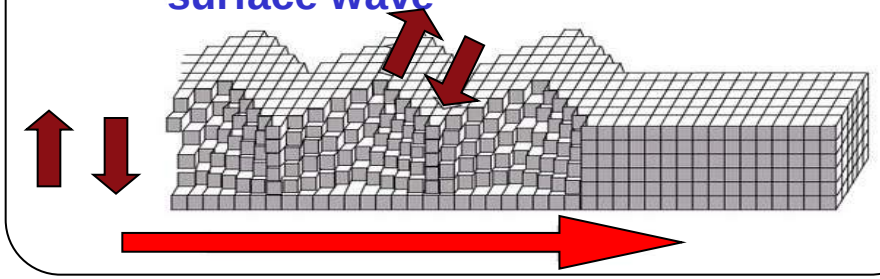
P-wave



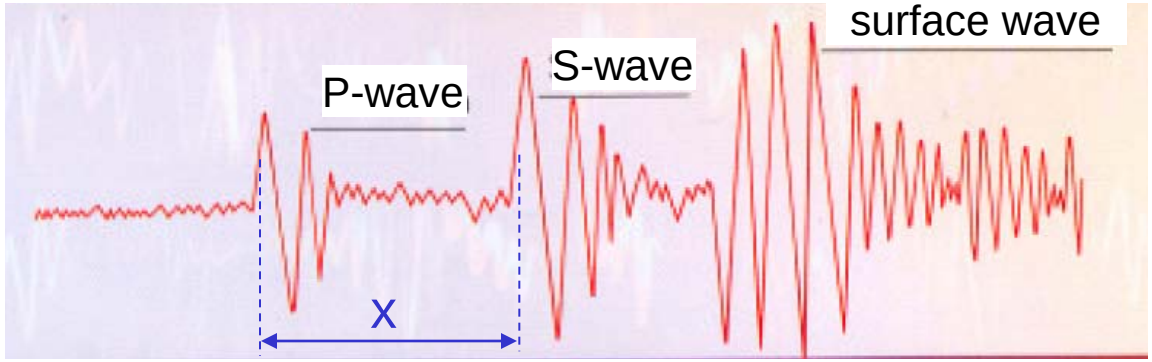
330 m/s **air**
1.420 m/s **water**

5.000 m/s **granite**

surface wave

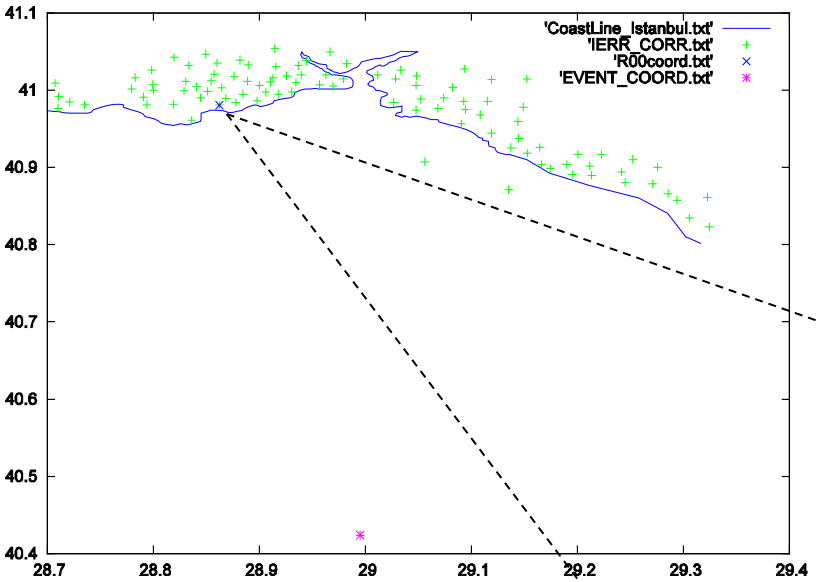


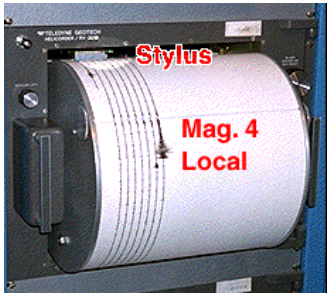
acceleration
(one dimension)



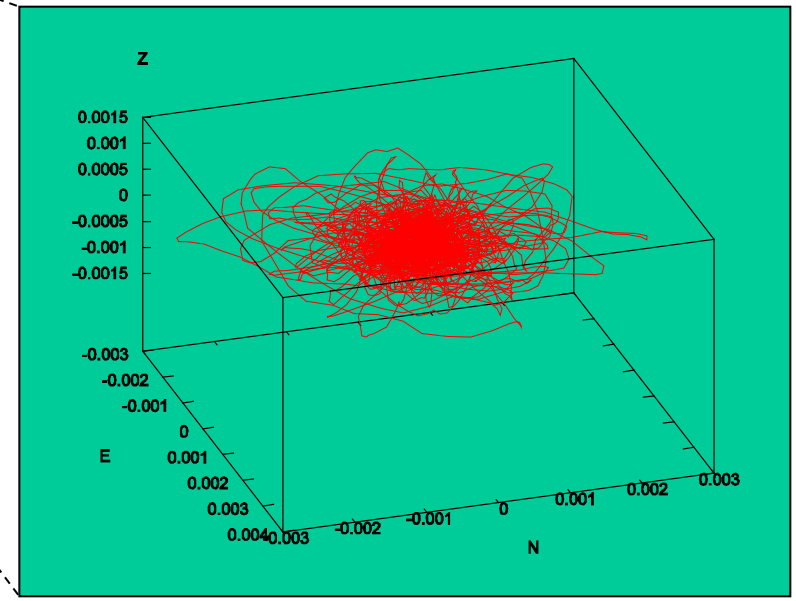
time

Lokale Bodenerschütterung

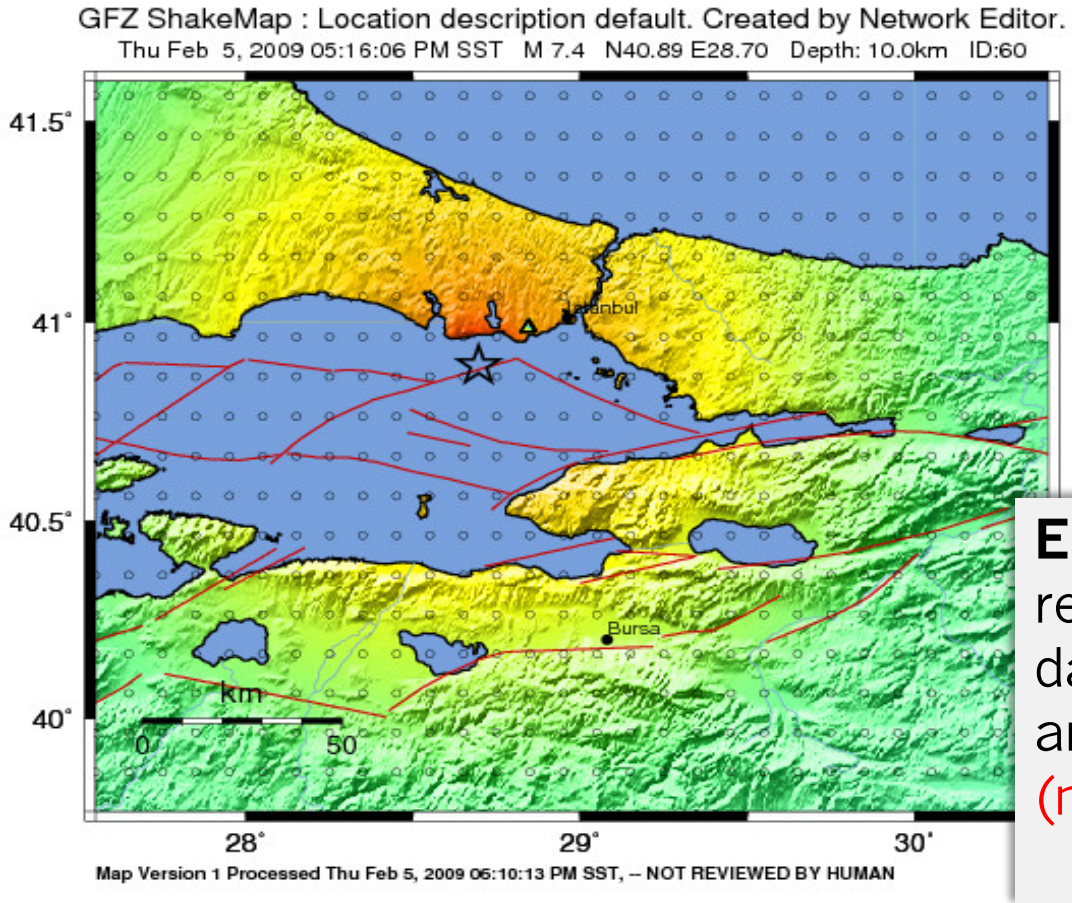




Traditionelle Seismometer



Early Warning and Rapid Response

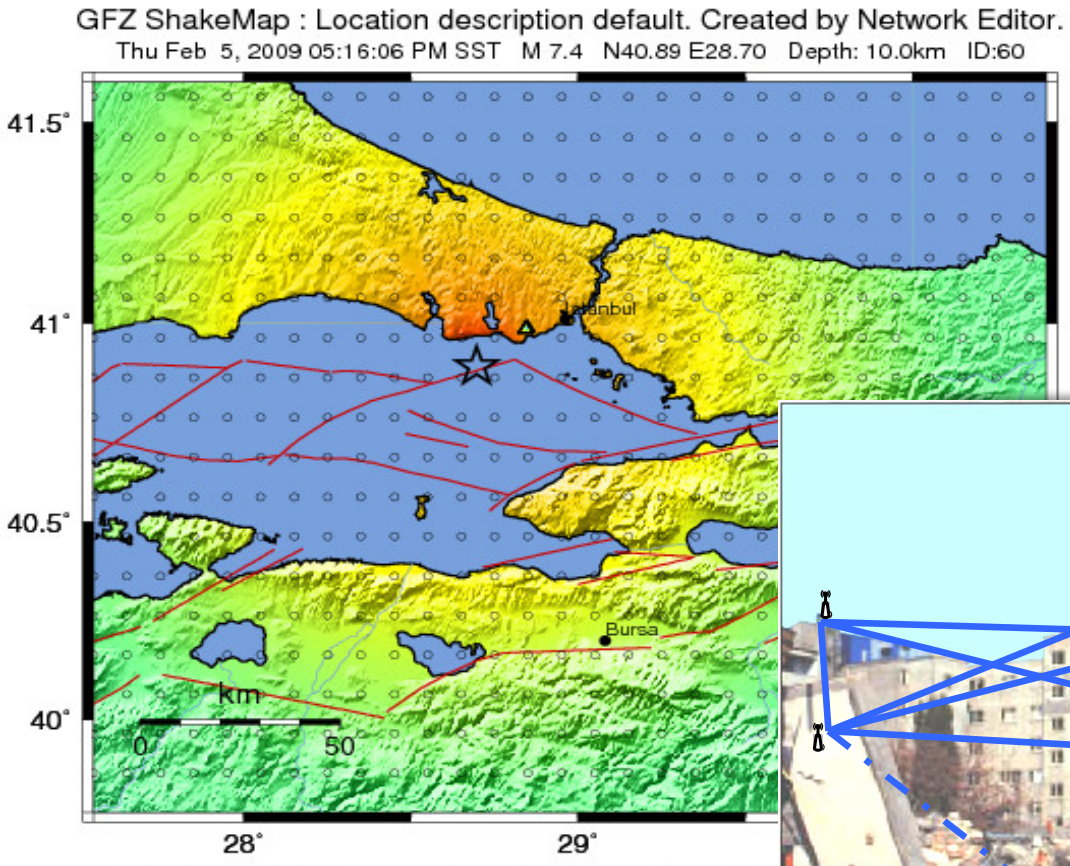


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Rapid Response
disaster estimation after an event in short time period

Early Warning
reaction before dangerous seismic waves arrive the city
(no prediction of an event)

Early Warning and Rapid Response



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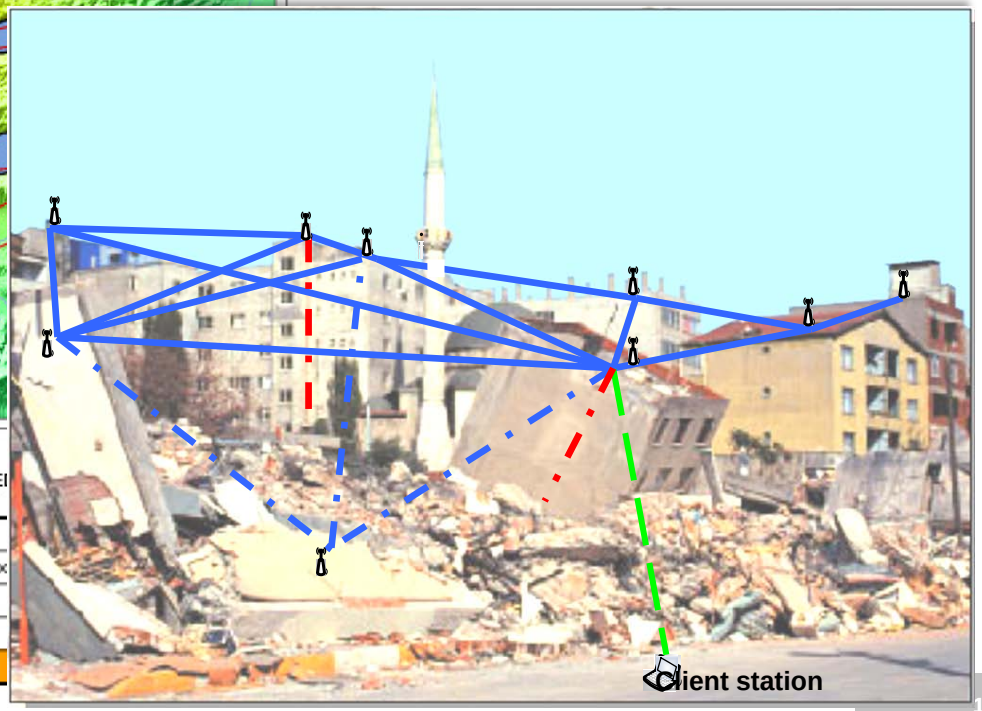
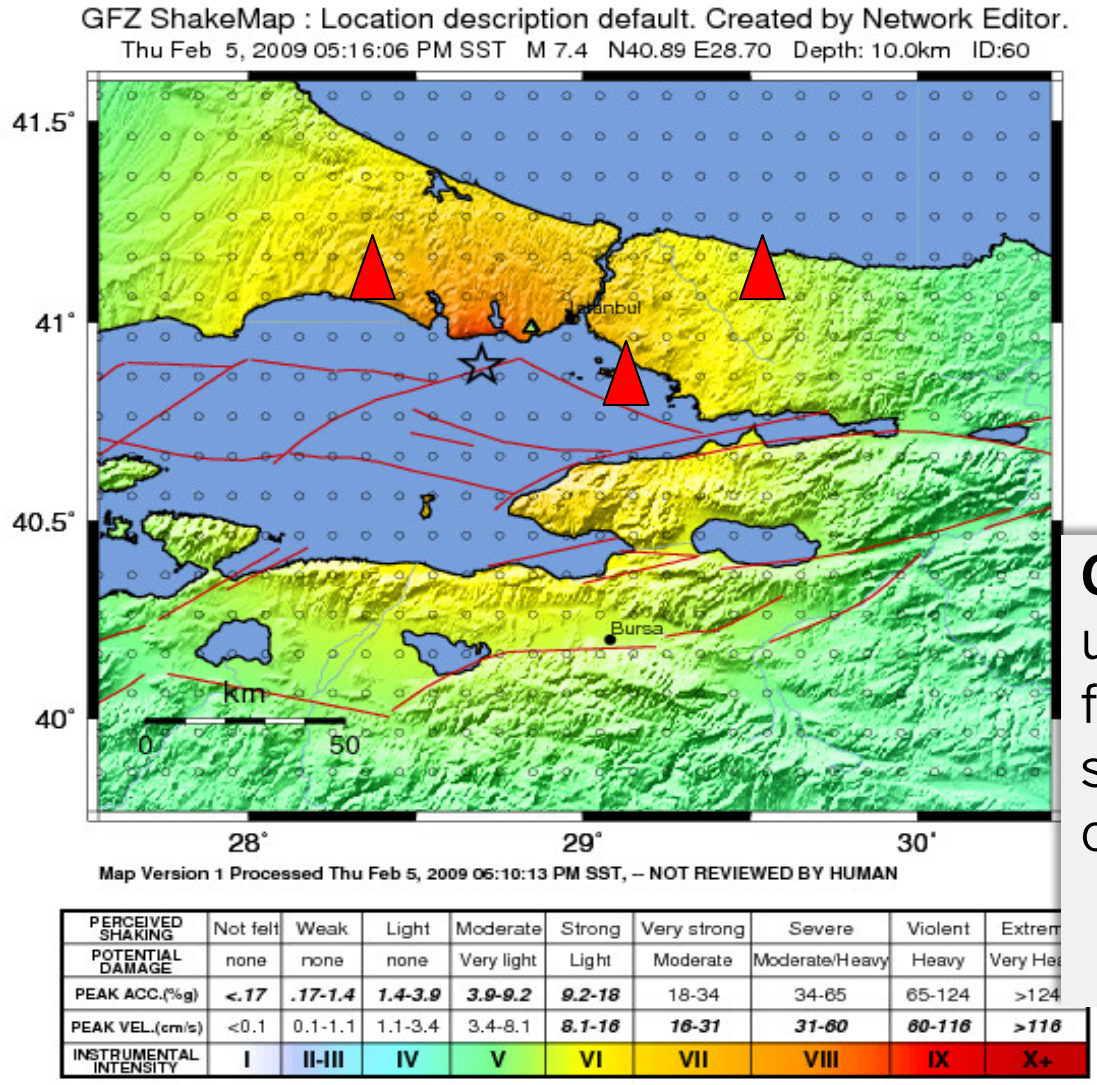


Early Warning and Rapid Response



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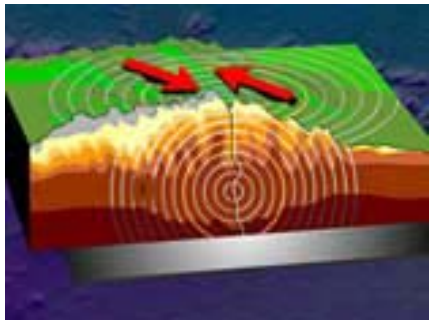
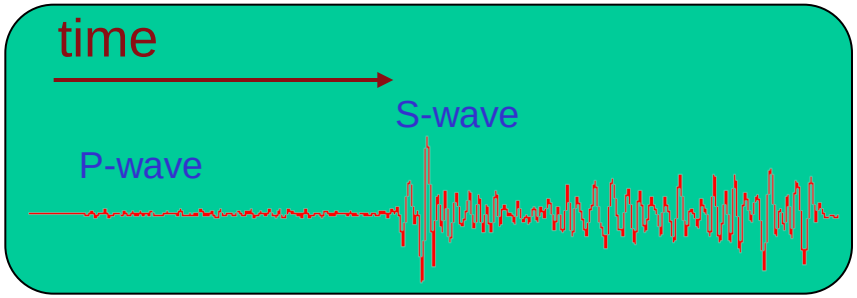
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Rapid Response
disaster estimation after an event in short time period

Current Technology
unsuitable extrapolation of few high sensitive seismometer stations out-of-city

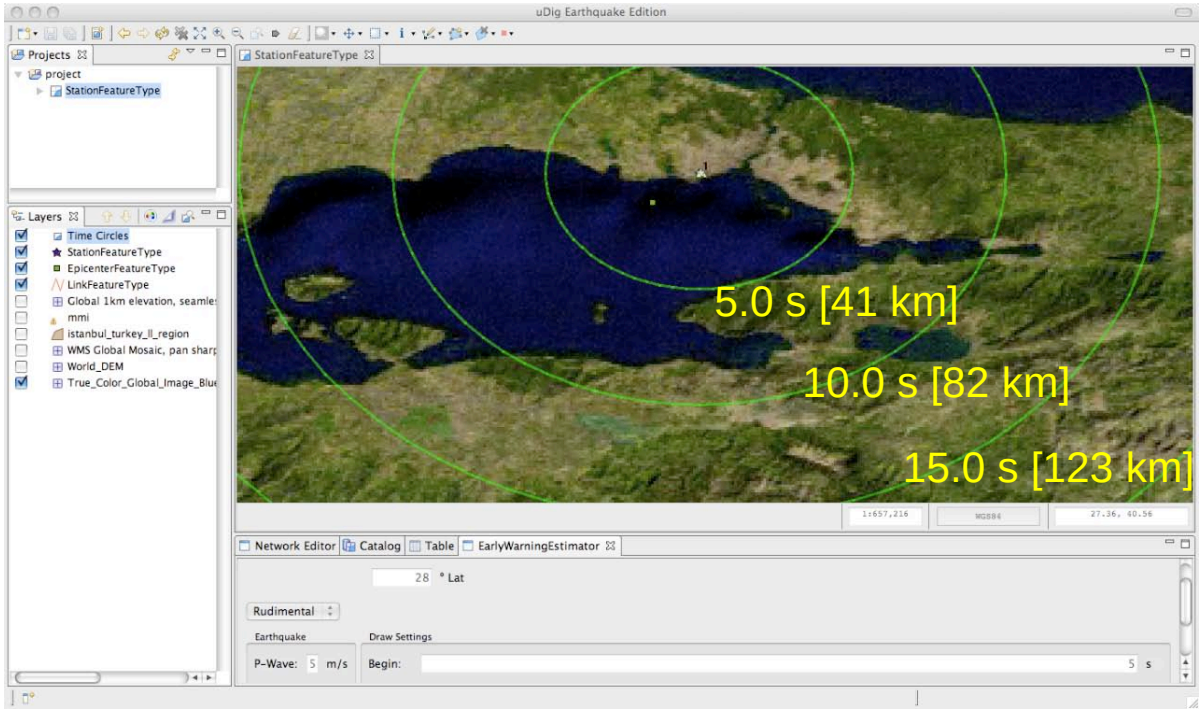
Physical Base of Early Warning





acceleration [cm s^{-2}]
of one
of 3 dimensions

5.000 m s^{-1} **granite** 3.000 m s^{-1} **granite**



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SOSEWIN-Grundidee

(Aufbau eines selbstorganisierendes Frühwarnnetzes durch private Haushalte)

- preiswerte Sensorik,
- direkte iNstallation in der Stadt

(Koopertion der Knoten notwendig: Fehlalarmausschaltung)

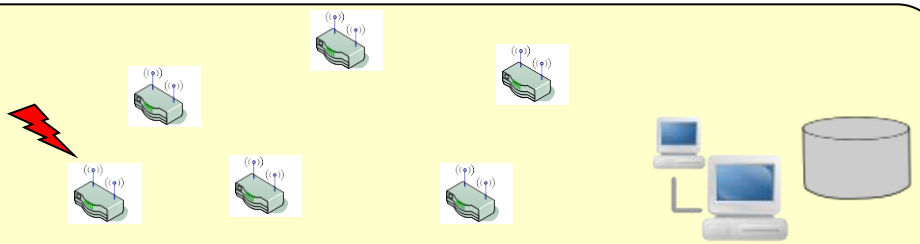
SOSEWIN-Alarmierungsprotokoll

weitere SOSEWIN-Ausbaustufen

Bekannte Frühwarnsystemarchitekturen und unsere Ideee

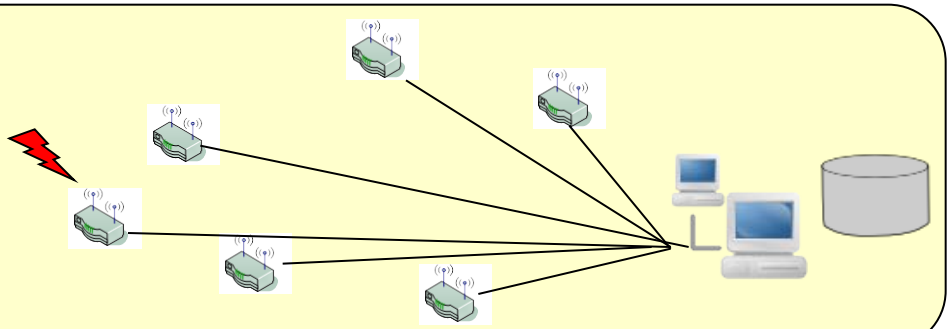
isoliert

- teure empfindliche Seismometer (5.000 – 20.000 € / Gerät)
- fern ab von Städten



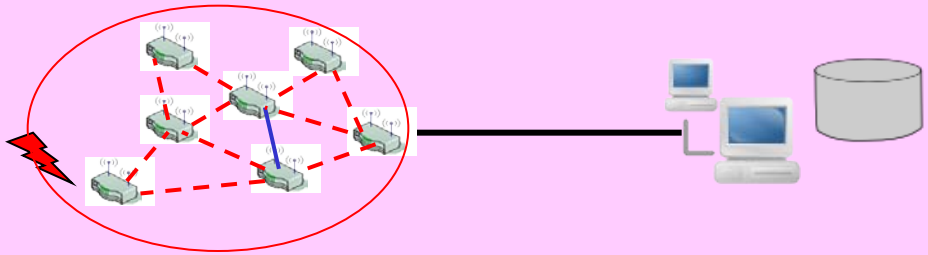
verbunden per Kabel

- teure empfindliche Seismometer
- fern ab von Städten

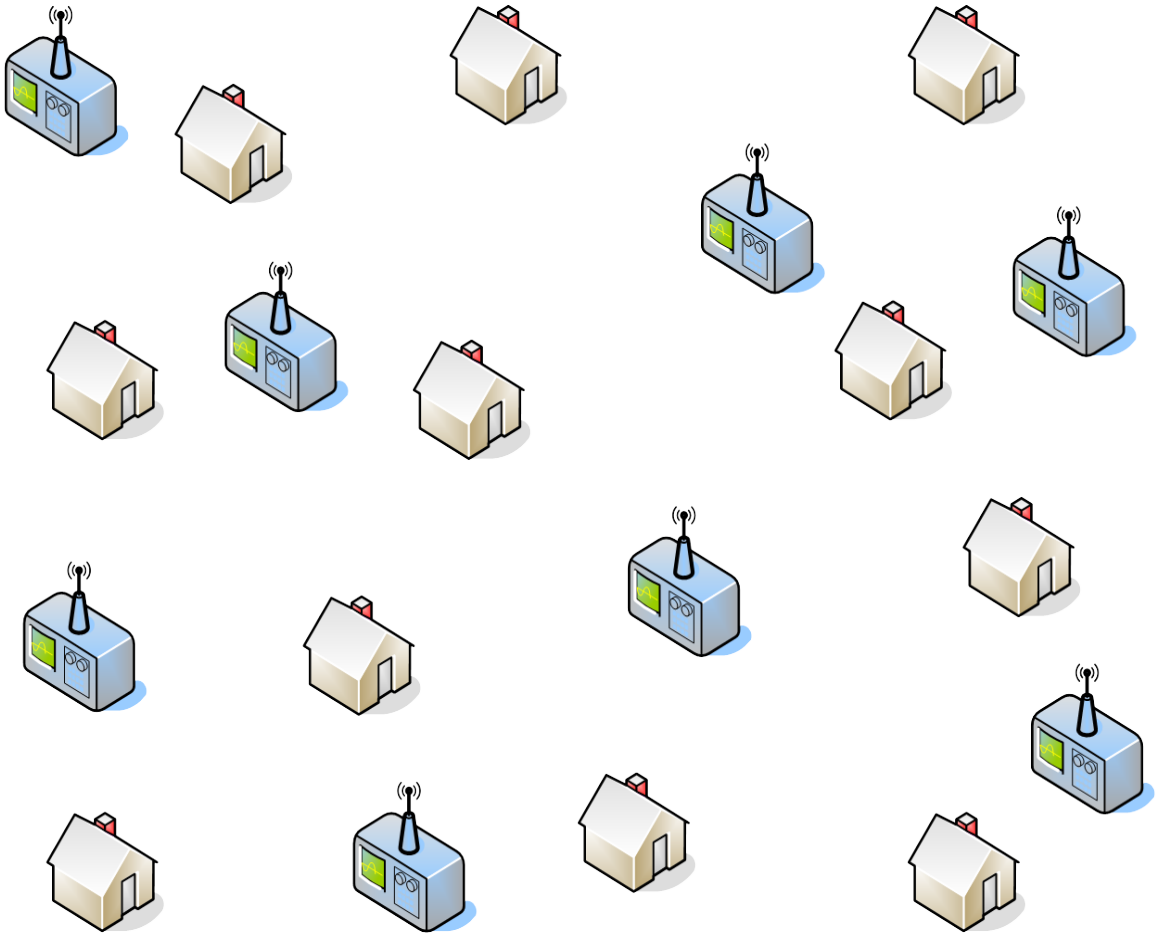


drahtlos verbunden

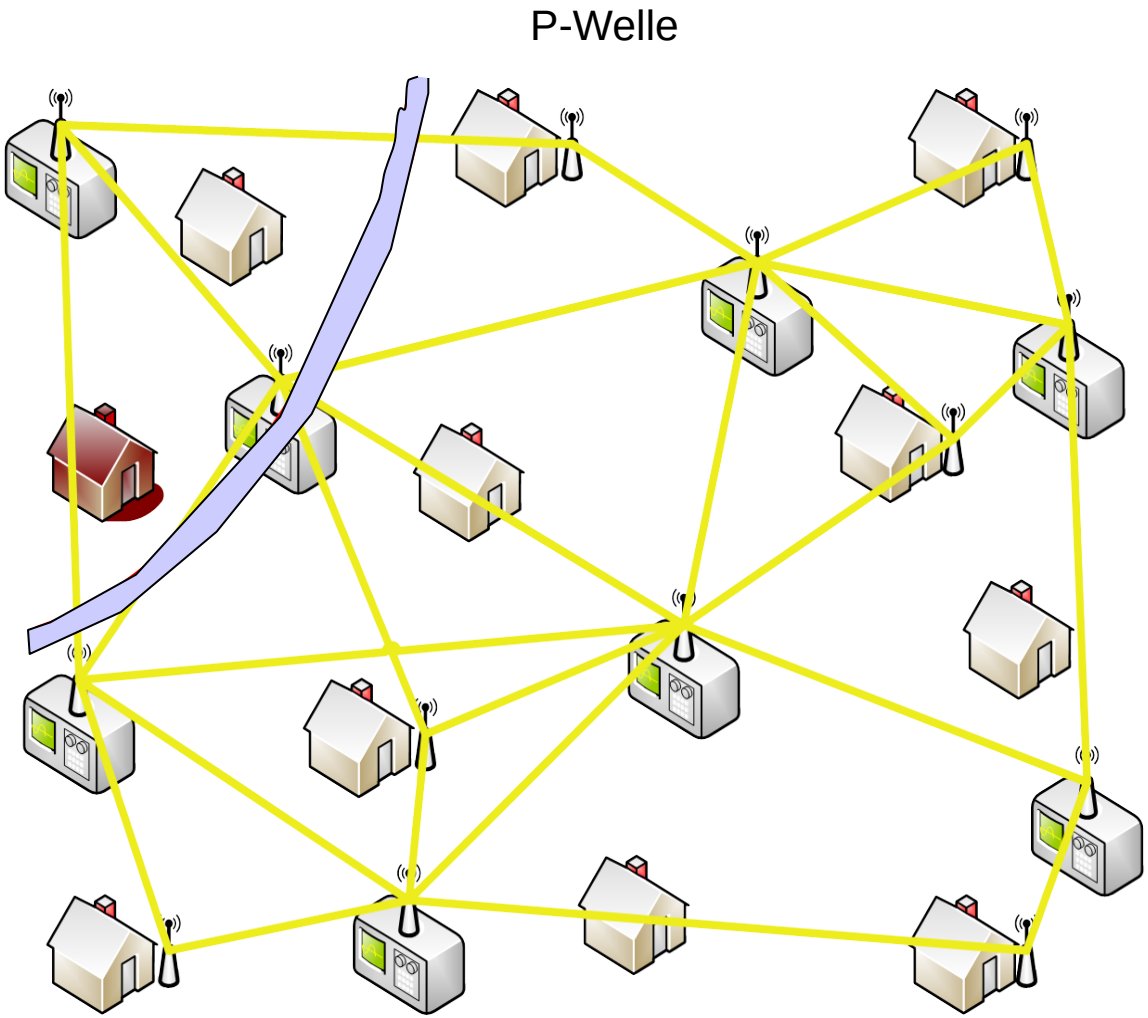
- preiswerte Seismometer (600 € / Knoten)
- direkt in den Städten



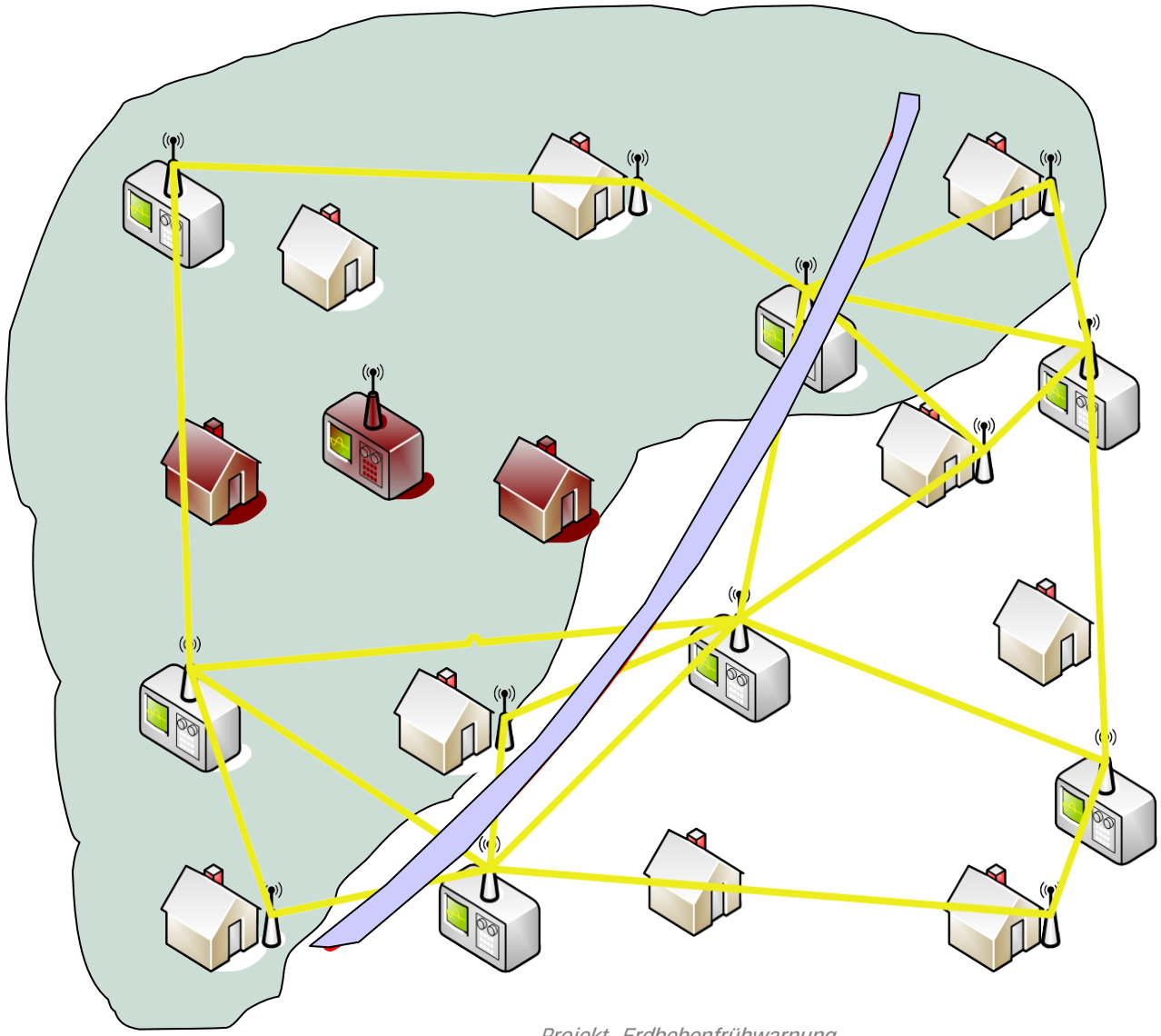
Unser Warnsystem – alles ist noch ruhig



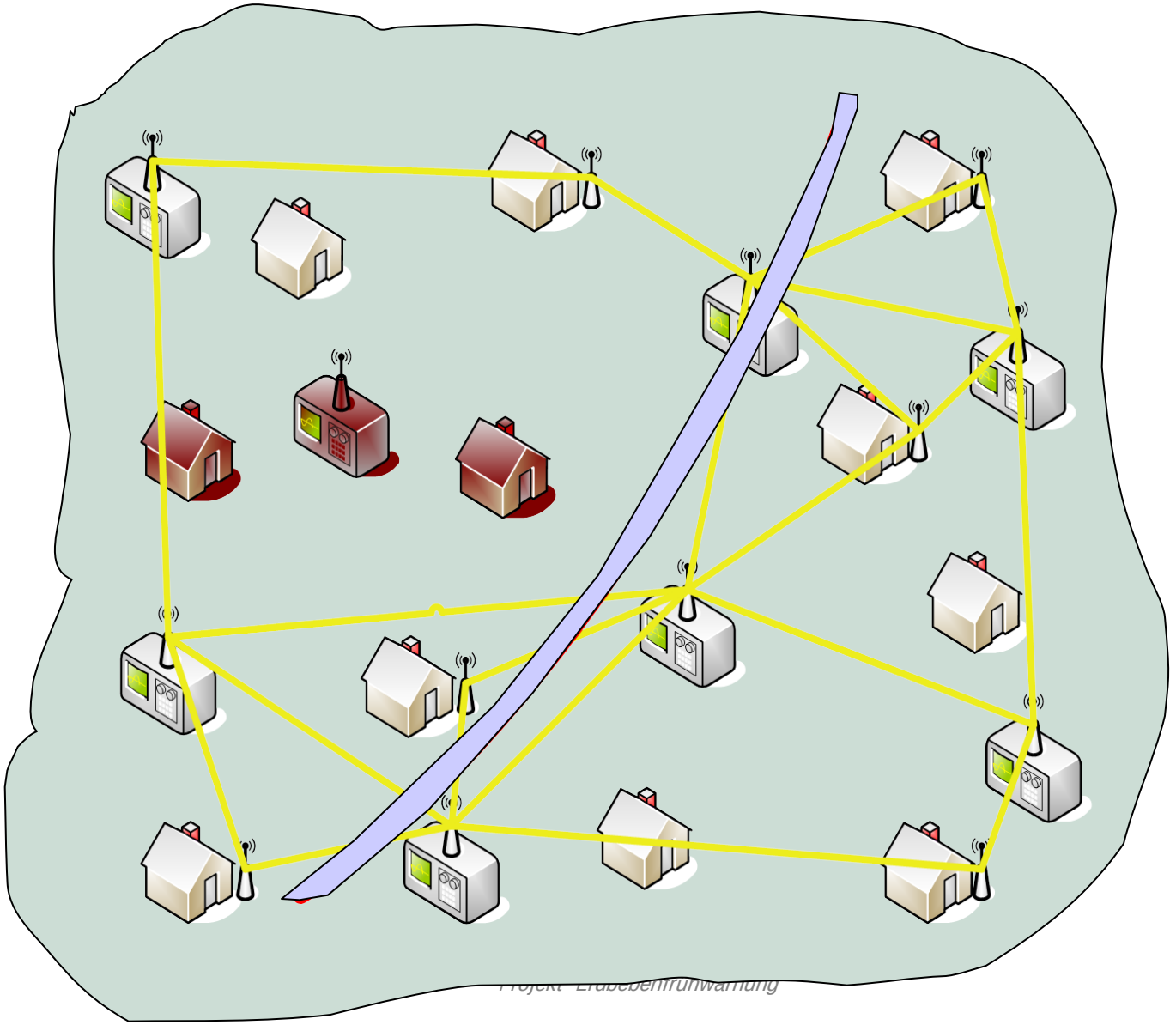
Die erste Station erkennt eine P-Welle



Die ersten Nachbarhäuser werden gewarnt

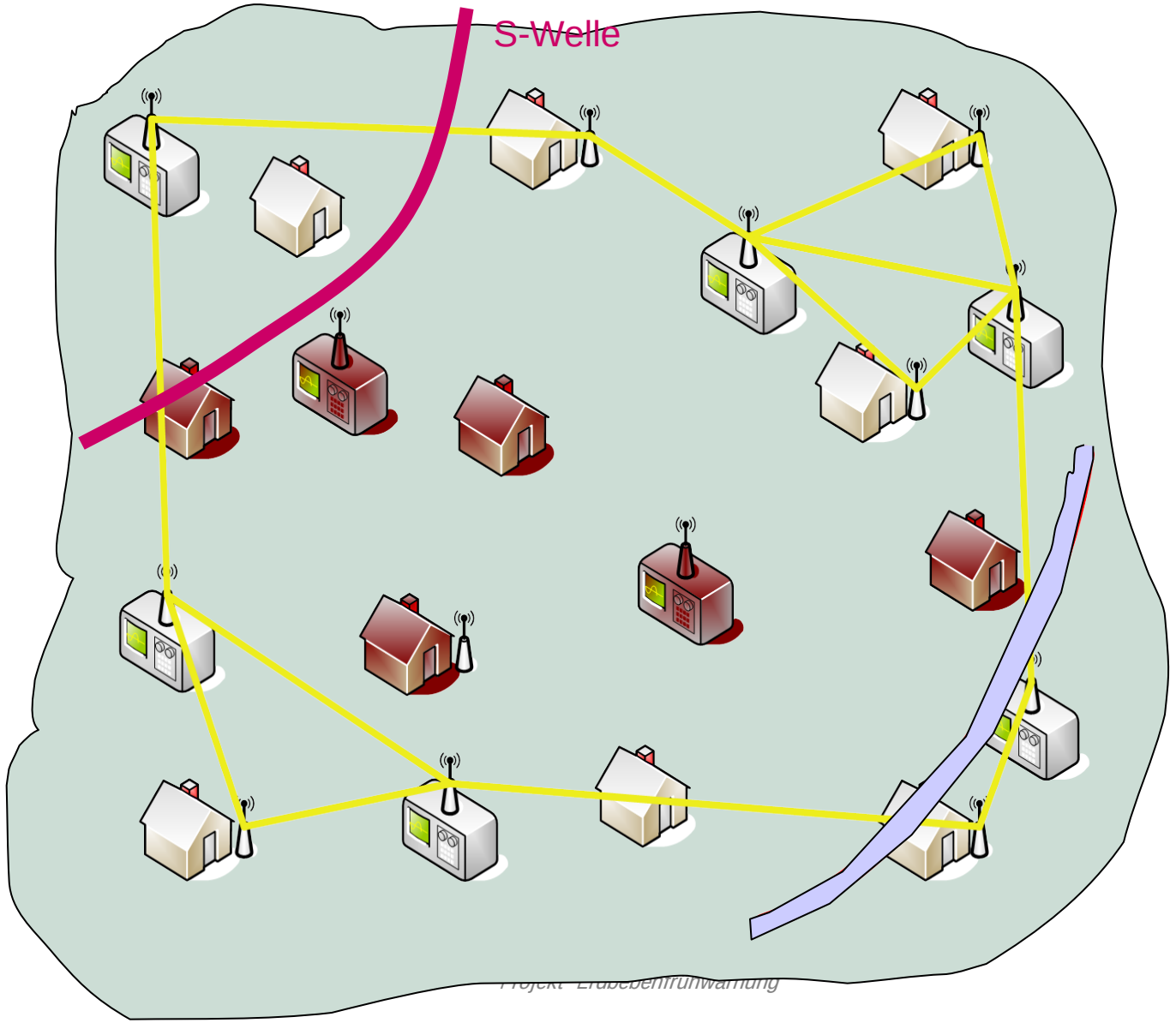


Wir warnen alle in unserer Nähe



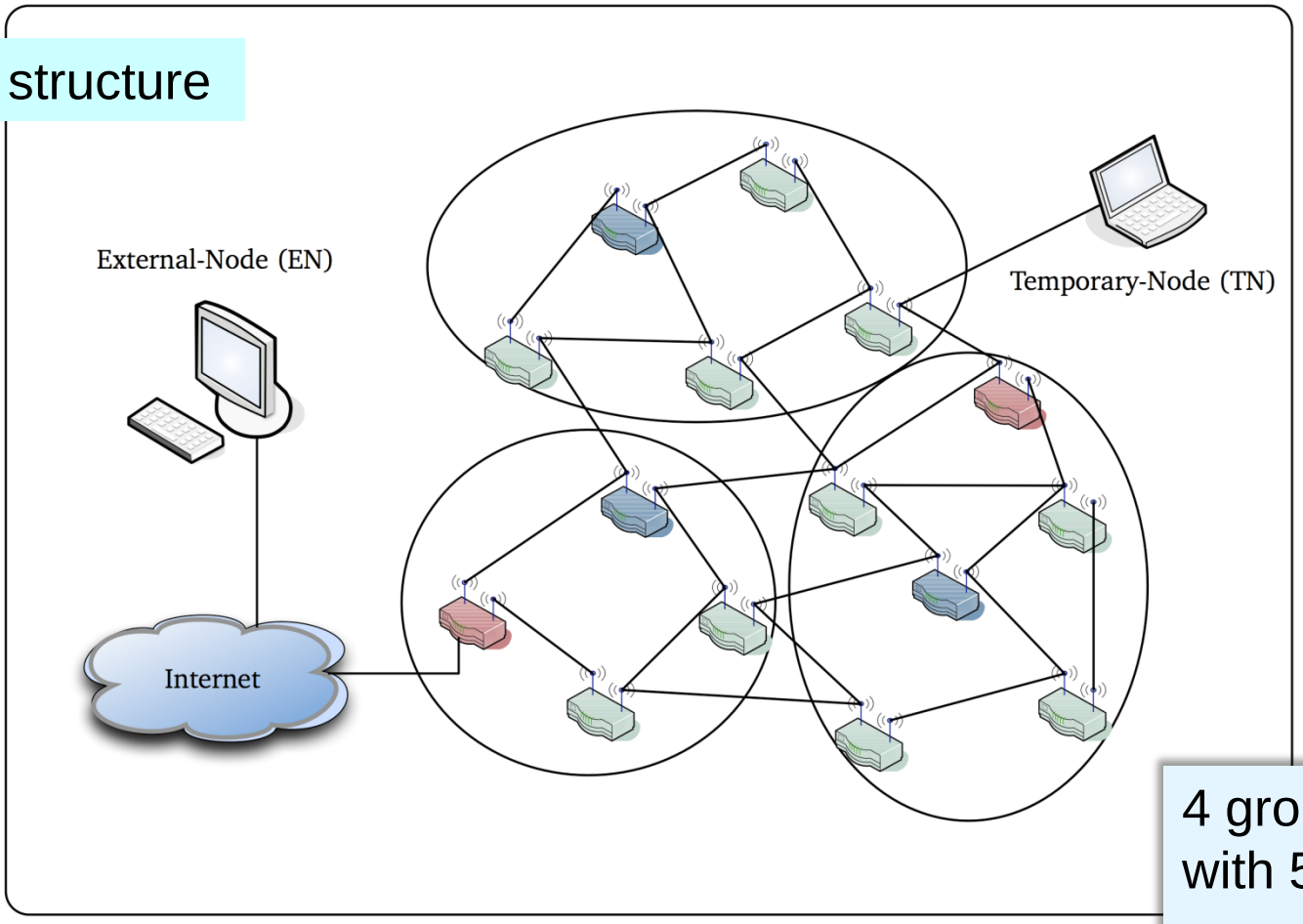
Alle Nachbarn wissen nun:

Die S-Welle kommt



SOSEWIN – Net Topology

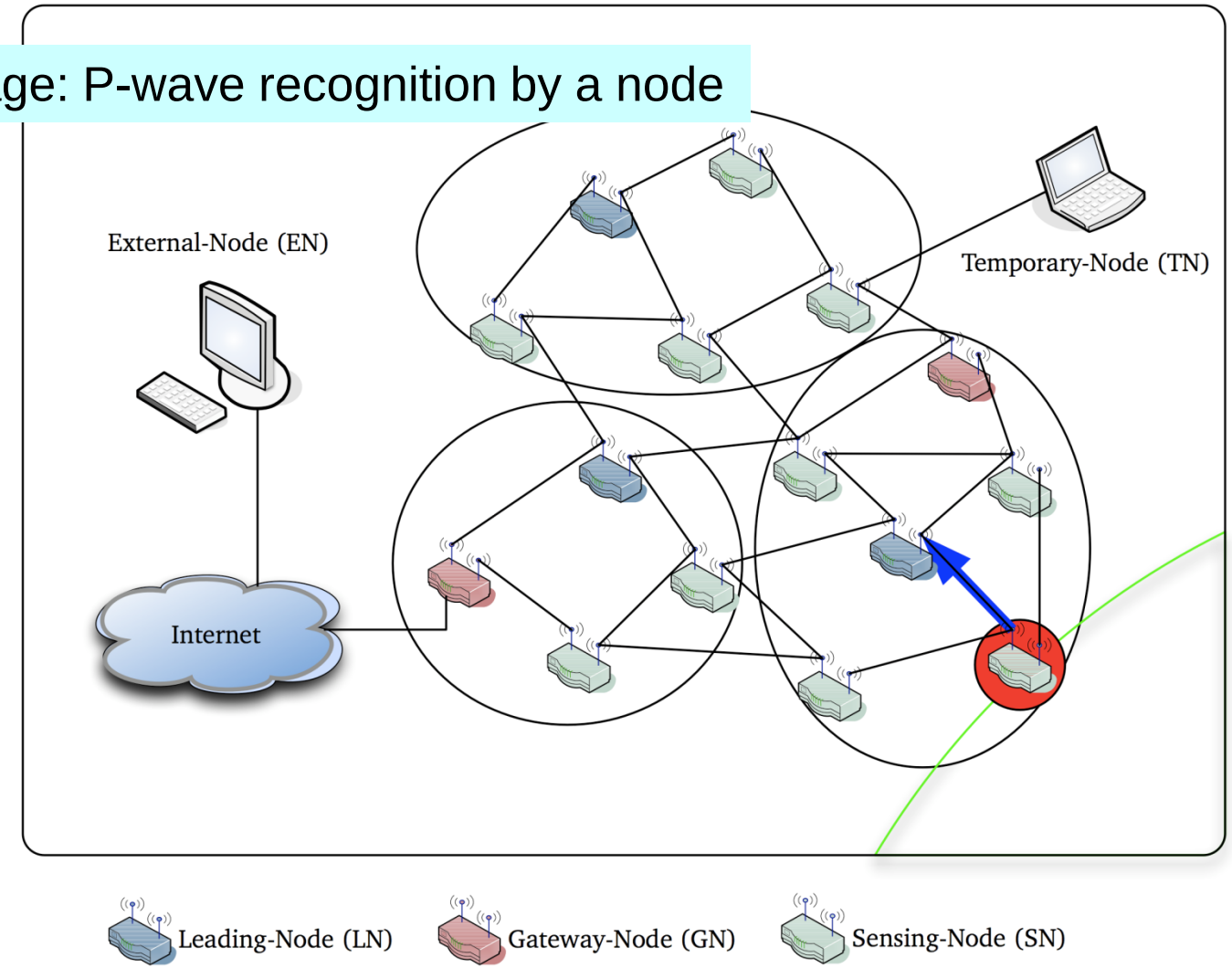
group structure



4 groups
with 5 nodes

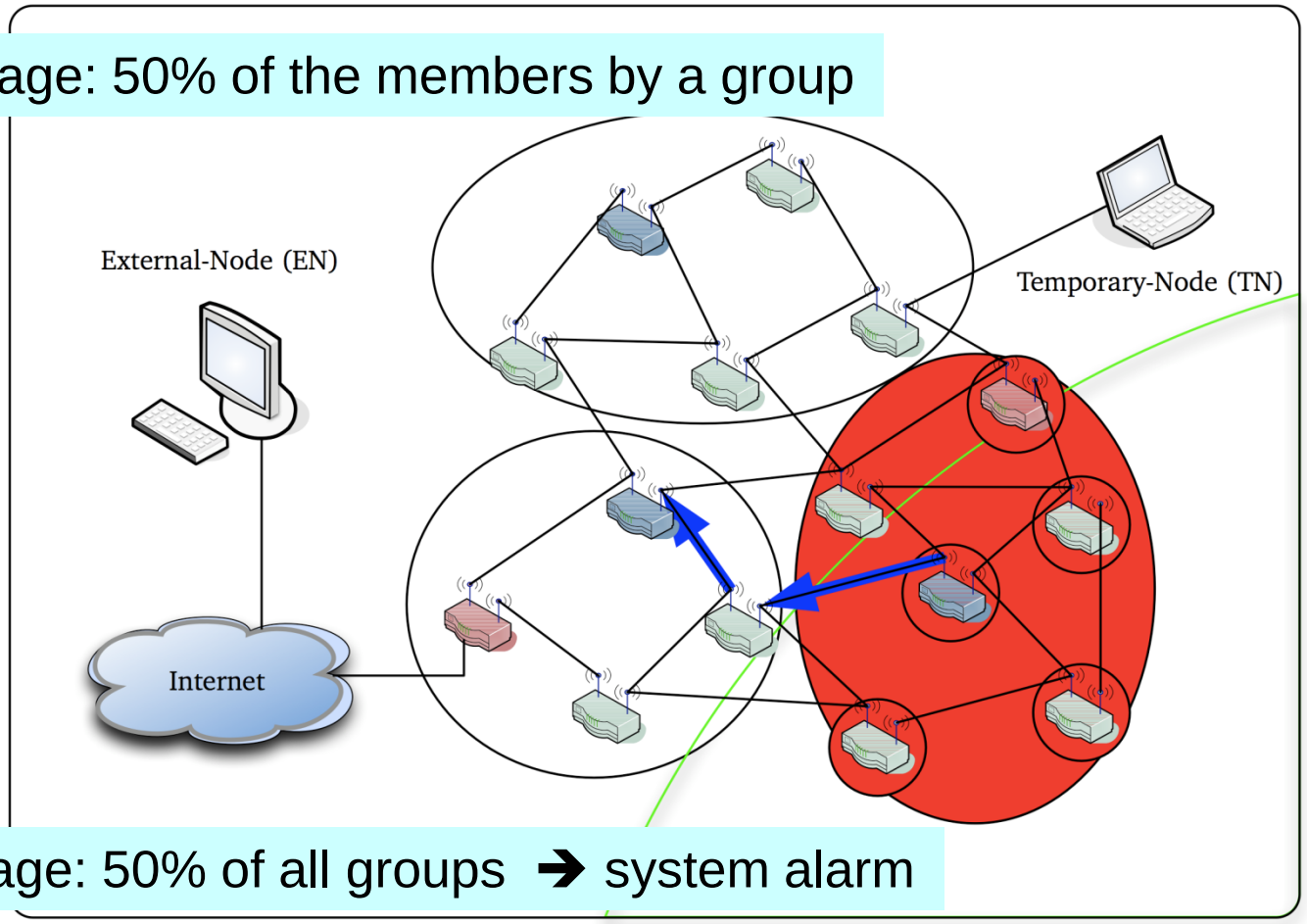
SOSEWIN – 3-Stage Alarming Protocol

1st Stage: P-wave recognition by a node



SOSEWIN – 3-Stage Alarming Protocol

2nd Stage: 50% of the members by a group



3rd Stage: 50% of all groups ➔ system alarm

Leading-Node (LN) Gateway-Node (GN) Sensing-Node (SN)

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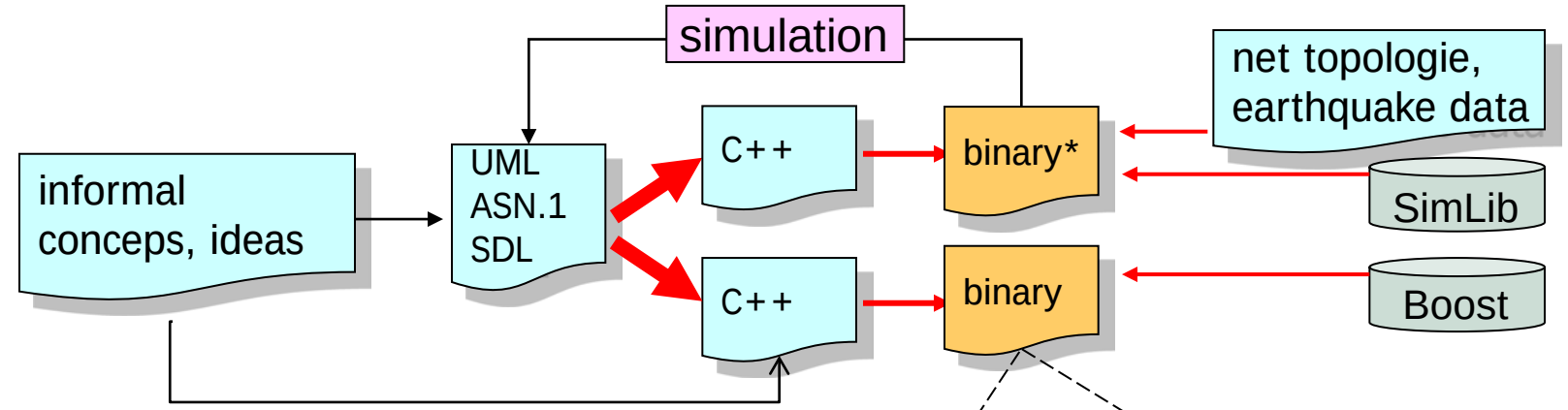
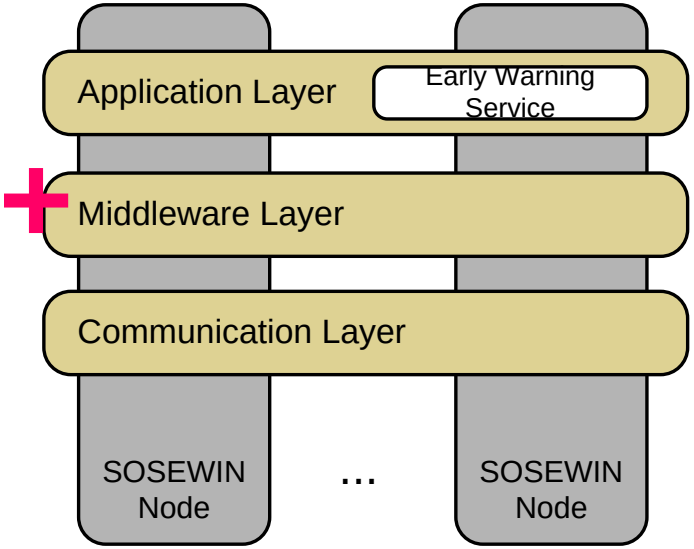
Modellbasierte Entwicklung

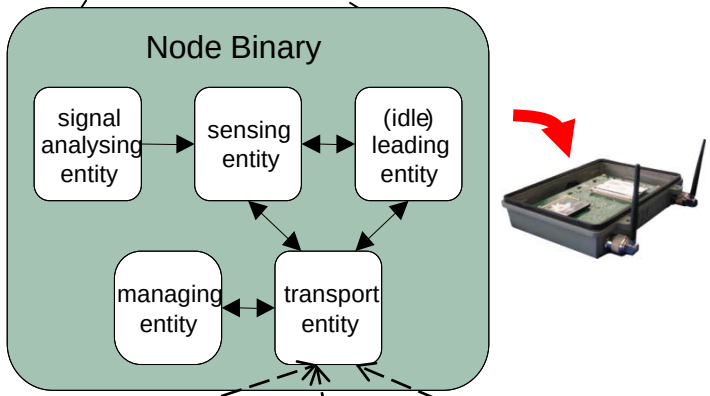
(Was kann modelliert werden?
Was kann mit Modellen angestellt werden?
Können Modelle zum Testen und zur automatischen Codeerzeugung genutzt werden?)

SOSEWIN-Entwicklungsumgebung

Our Model-Driven Approach







PragmaDev
SDL/RT
simulator

network
simulators

openWRT
ASN.1 coding
(real/virtual)

in dependence of the
communication infrastructure

Basic Development Requirements

Seismic Part

- test material for earthquake events (wave descriptions for every node localisation)
  → data syntheziser (PDE solver)
- signal analysis (Pwave detection) Fortran → C++
- remote switch between real sensor and syntheziesd input for each node
- estimation of shakemaps

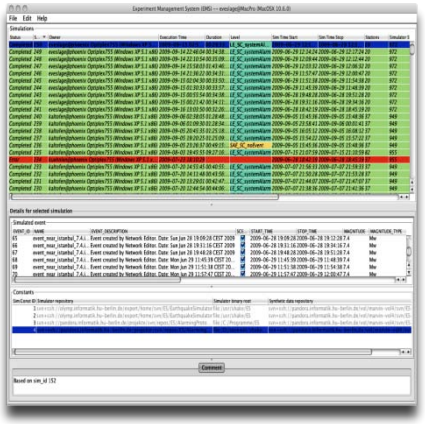
IT Part (SAM)

- **IT Part (SAR)**
  - Identification of hardware and OS
  - OLSR adaptation (Spezifik), Bandbreitenapassung
  - Network time synchronisation
  - Seismic influence on communication behaviour
  - SEISCOMP integration

Engineering Part

- long-term reliability test of hardware components and power-supply devices
- adapting node positioning

Experiment Management Syst



Executables

Earthquake Repository

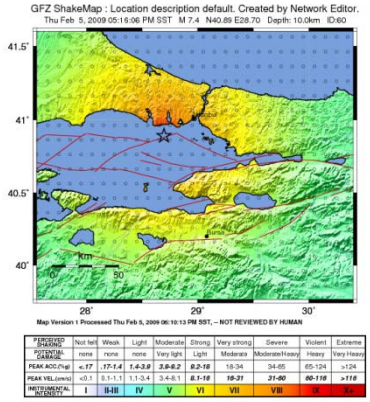
Earthquake Synthesizer

Experiment Repository

Simulation

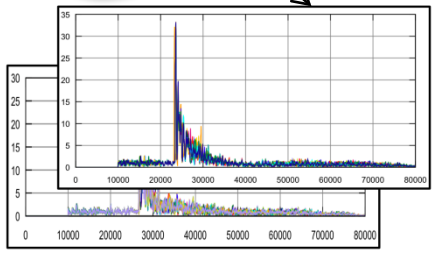
Virtualisation

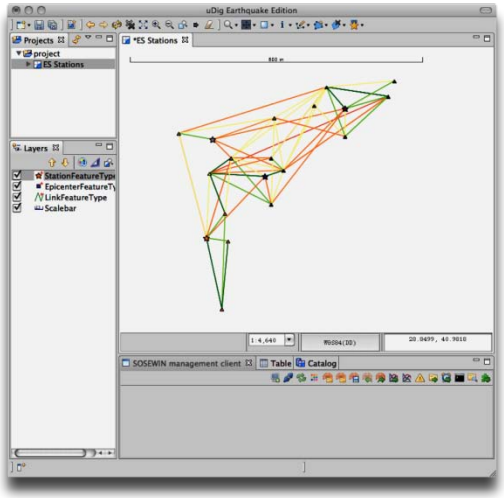
Real World

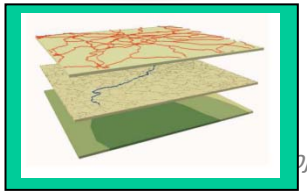


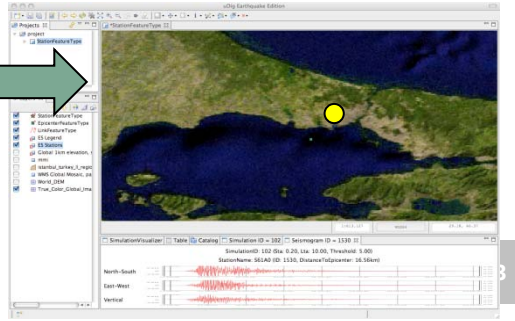
Log File

XML





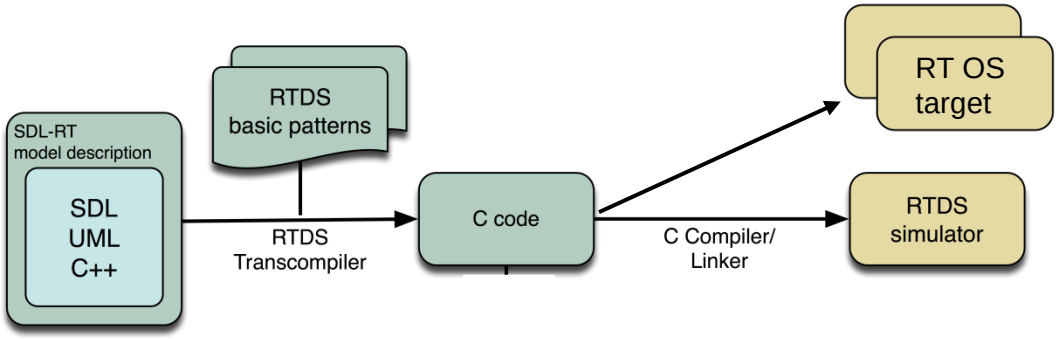




GIS based editor

Approach

Use of PragmaDevs SDL/RT Compiler



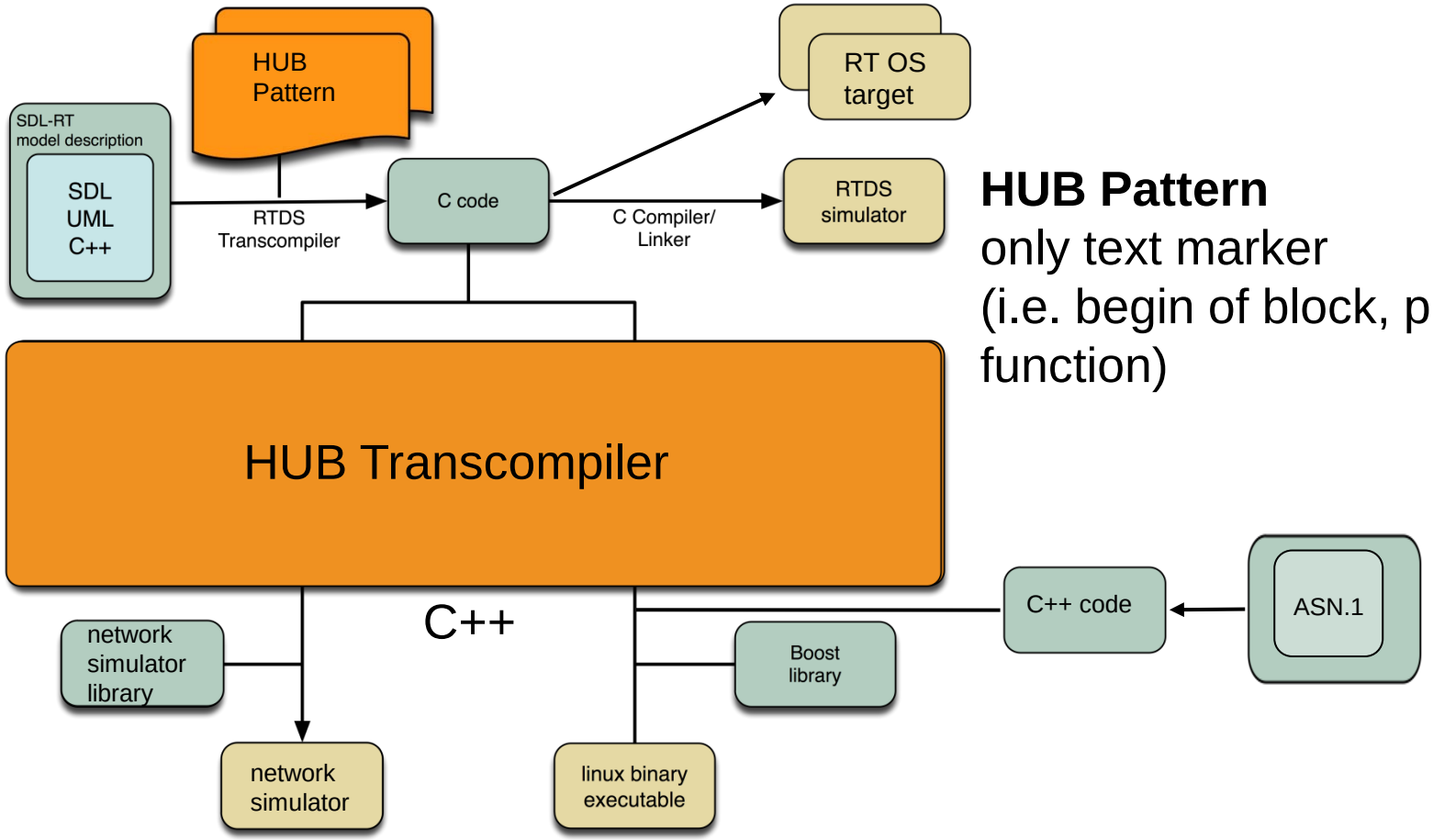
RTDS basic Pattern
C static code fragments and Makros (i.e. signal sending)

Useful Pragmatics
- SDL / UML / C++
- pointer/reference variables (as signal parameters)
- process priorities, semaphore controlled global variables
- flexible code generation for RT OS

Language Deficits
- missing timer parameterization
- block (type) local process sets become system global (problem for a process-name-based signal addressing)
- no support for code generation for distributed systems

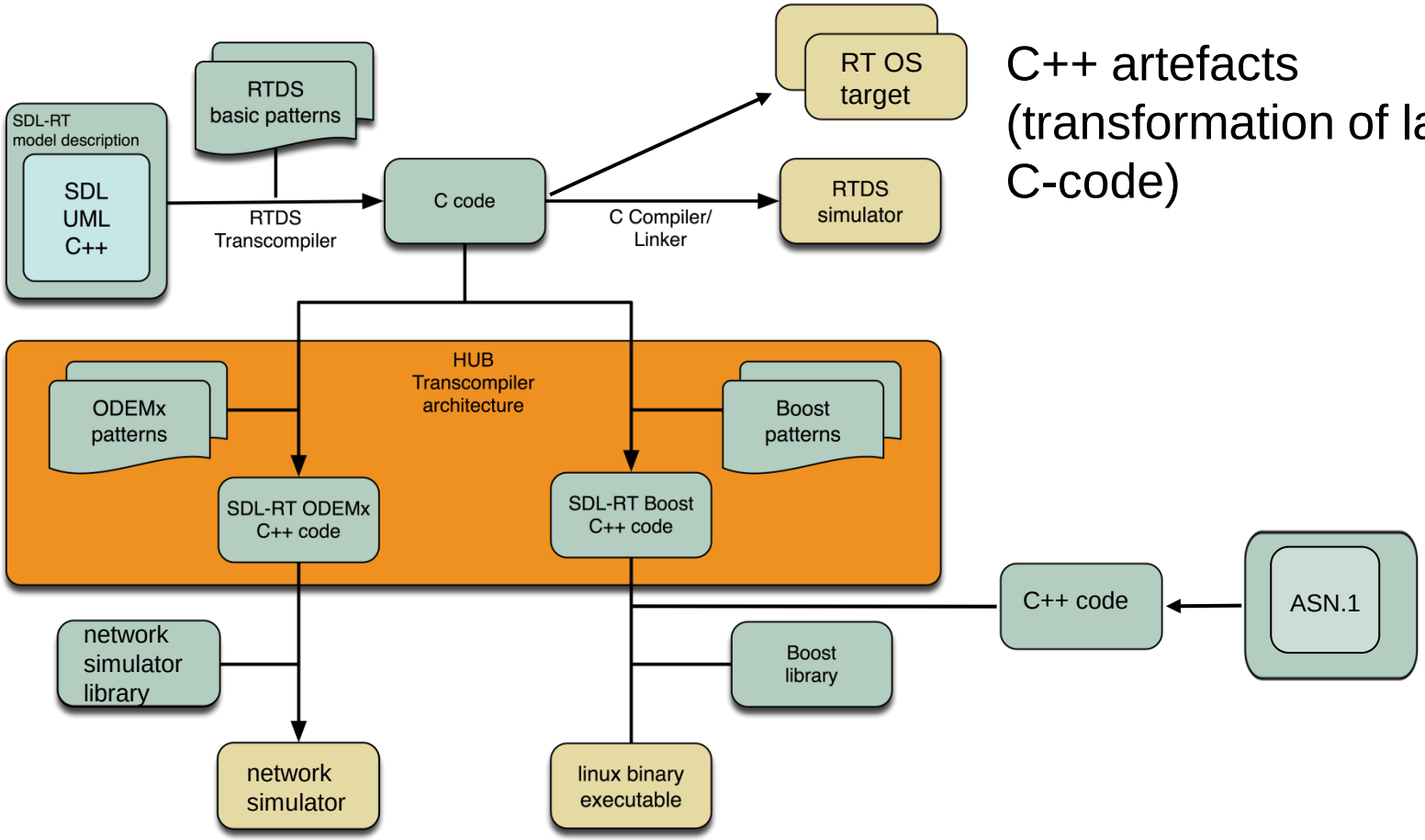
Extension of PragmaDevs SDL/RT Compiler

SDL / UML / C++ / ASN.1 ➔ C++



HUB Pattern
only text marker
(i.e. begin of block, process, function)

Extension of PragmaDevs SDL/RT Compiler



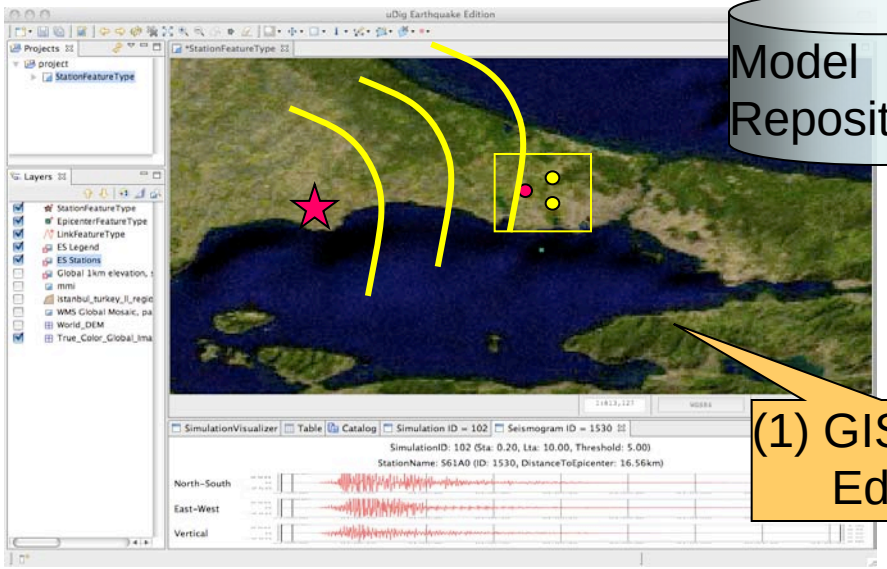
ODEMx/Boost Pattern

C++ artefacts (transformation of labelled C-code)

Benötigte Simulatoren

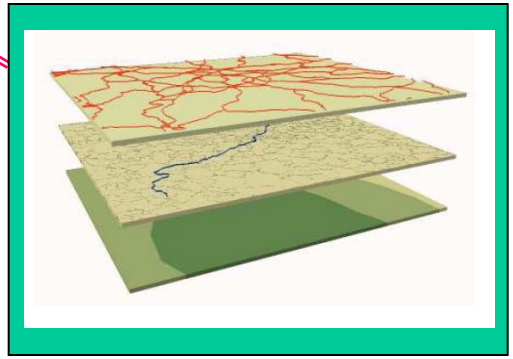
- Erdbebenwellenausbreitung
  - Epizentrum, Tiefe, Stärke, Bruchzonenbeschreibung
- Knotenfunktionaliät
  - Unterschiedlicher Netzwerkschichten bei Variation von Routing-Protokollen
  - Unterschiedlicher Topologien
  - Unterschiedlicher Störungseinflüsse
- bei Einbindung in ein Geo-Informationssystem

Models, Target Components, and Tools



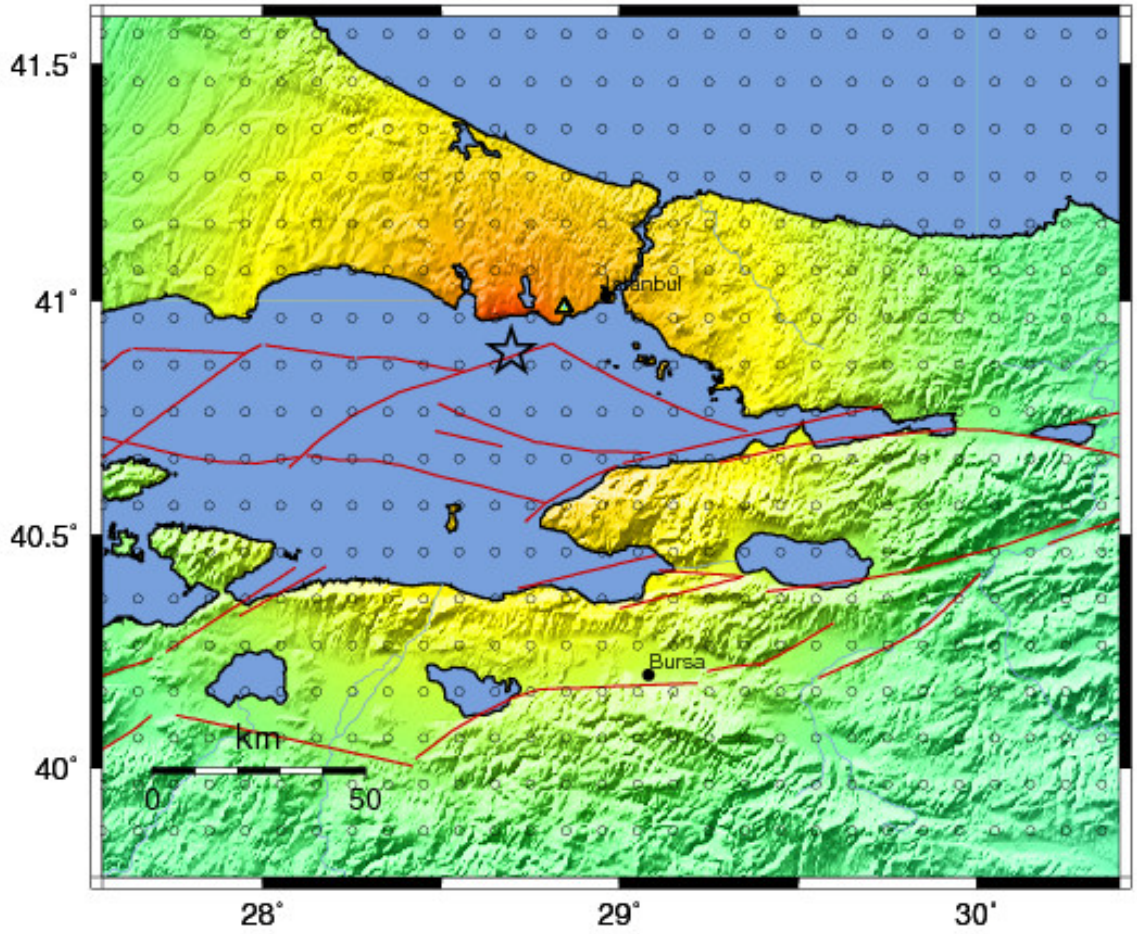
Model Repository

(1) GIS-based Editor



GFZ ShakeMap : Location description default. Created by Network Editor.

Thu Feb 5, 2009 05:16:06 PM SST M 7.4 N40.89 E28.70 Depth: 10.0km ID:60



Map Version 1 Processed Thu Feb 5, 2009 06:10:13 PM SST, -- NOT REVIEWED BY HUMAN

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

1. Einführung

1. Experimentelle Basis: SOSEWIN-Prototyp
2. Etwas zu Erdbeben und Frühwarnung
3. Unser Konzept einer Erdbebenfrühwarnung
4. Unser modelbasieter Entwicklungsansatz
5. Aktuelle SOSEWIN-Einsatzfälle

Current Cases of Operation

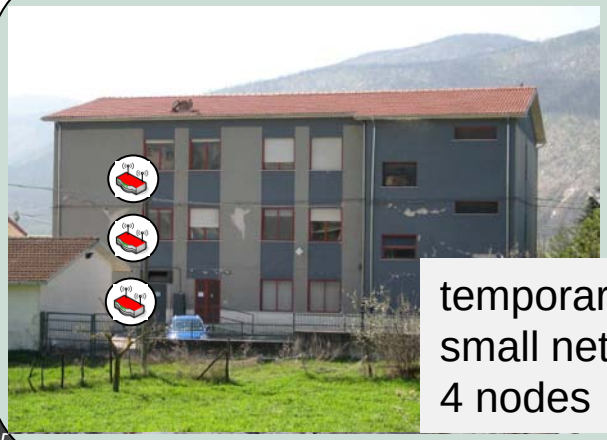
SOSEWIN, Istanbul

remote
managed
meshed
seismometer
network

Fatih Sultan Mehmet Bridge, Istanbul

temporary
4 single nodes

Task Force, L'Aquila



temporary
small net of
4 nodes

Water turbine, Munich

single nodes
high sensitive sensors

? ! !