Fine-Grained Geographic Communication (Geocast)

Nexus Workshop

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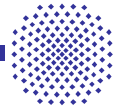
23.07.2003

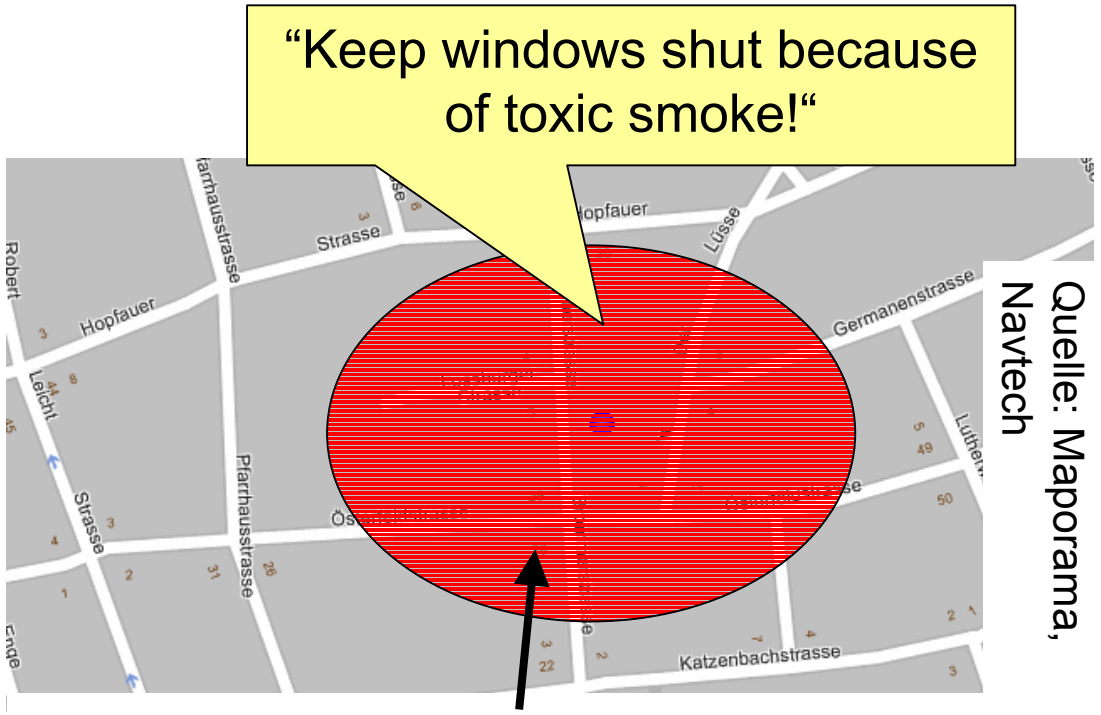
Overview

- Motivation
- Requirements for Fine-Grained Geocast
- Location Model for Fine-Grained Geographic Addressing
- Summary
- Related Work
- Future Work

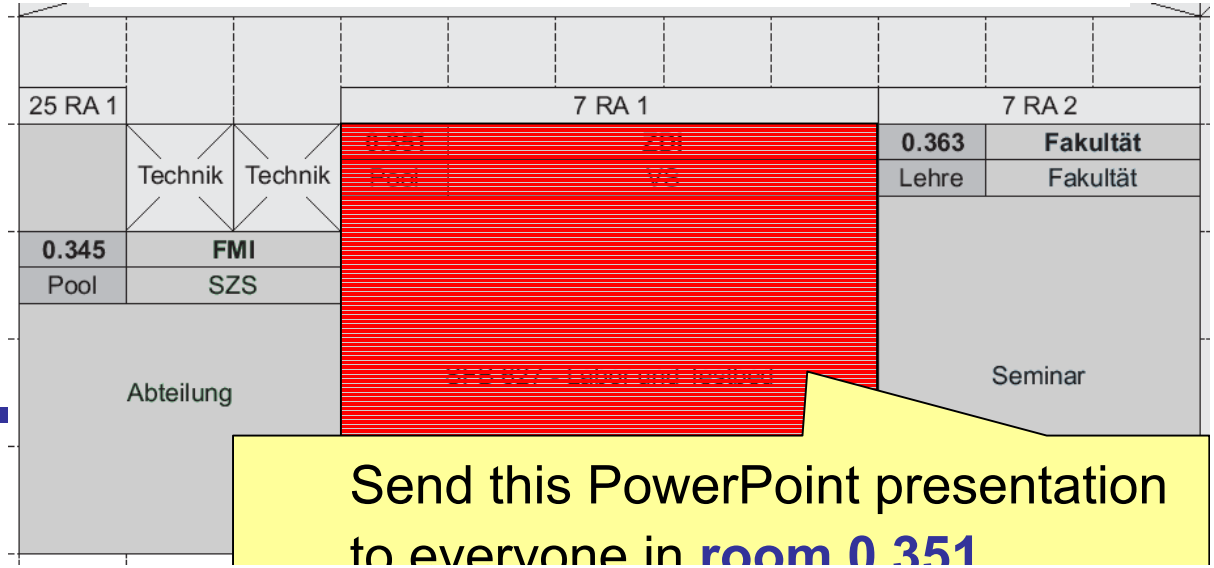


Motivation for Fine-Grained Geocast

- Geocast = Sending messages to users in certain geographic area
- Messages can be addressed
  - Geometrically
    - Polygons, circles, cubes, etc.
    - Arbitrary areas
    - Geometric pos. sys., e.g. GPS
  - Symbolically
    - Building/room numbers, etc.
    - Intuitive to use
    - Symbolic pos. sys, e.g. IR-based
  - Hybrid



circle(48.7340540N, 9.11159641E, 100)

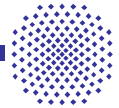


Requirements for Fine-Grained Geocast

- Fine-grained geographic addressing
  - Geometric addressing
  - Symbolic addressing
  - Hybrid addressing
  - Mobile target areas, e.g. trains, ships, etc.

  → Requires fine-grained **hybrid location model**
- Efficient Geocast Routing
  - Efficient message forwarding
  - Scalability
  - Easy integration in existing IP infrastructure
  - Fault tolerance

  → Routing protocols for fine-grained geocast



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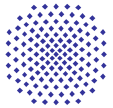


Role of Location Model for Geocast

- Target area definition
- Client position/area definition

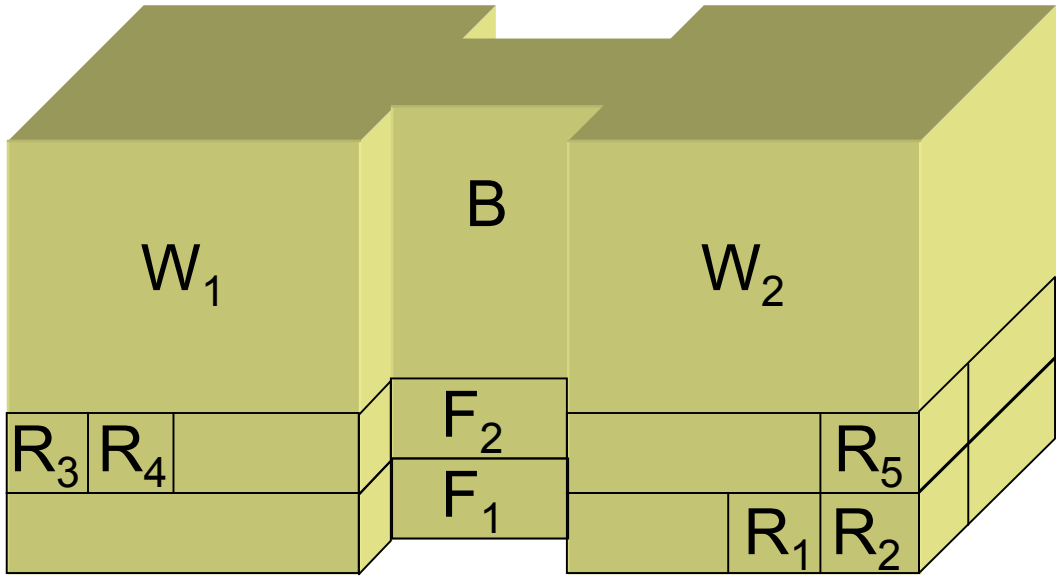
- Key question: “Is client inside target area?“
  - Comparison of target area and client position required
  - Problems
    - Inaccurate client positions

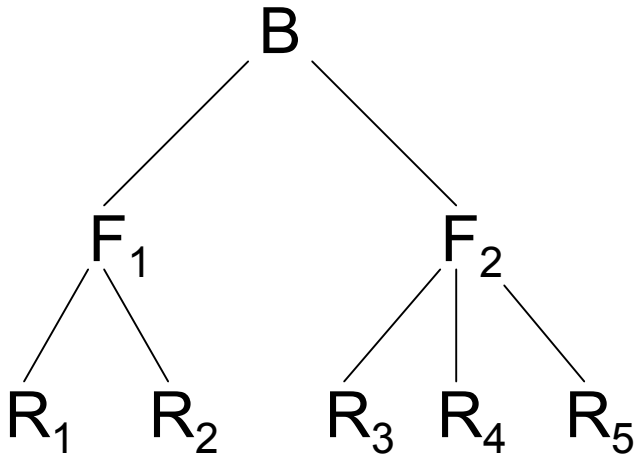
    → Probabilities for client being in target area
    - Heterogeneous target area and client areas

    → Translation of target area or client area

Hierarchical Symbolic Location Model

- Building contains floors; floors contain rooms → Hierarchy of locations

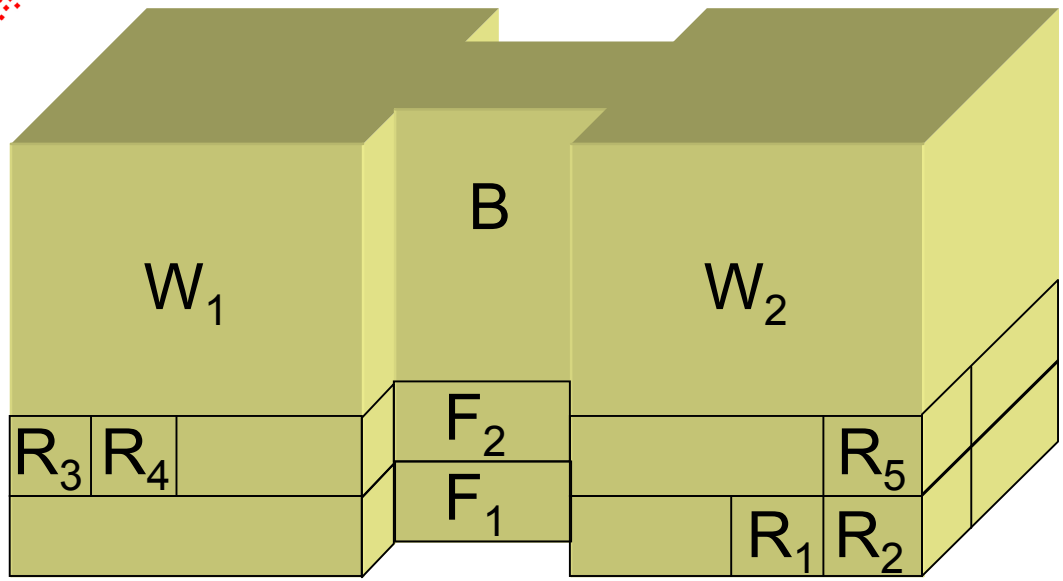


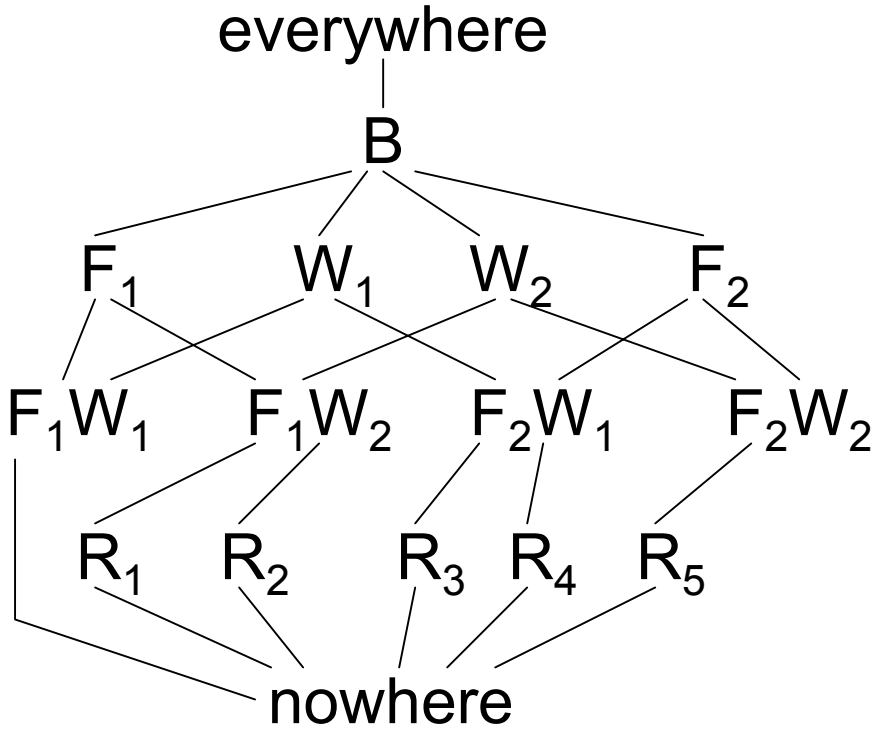


- Rooms are contained in floors ***and*** wings
- Floors are not contained in wings; wings not in floors
- Tree cannot reflect reality

→ Need of more powerful model

Lattice-Based Symbolic Location Model





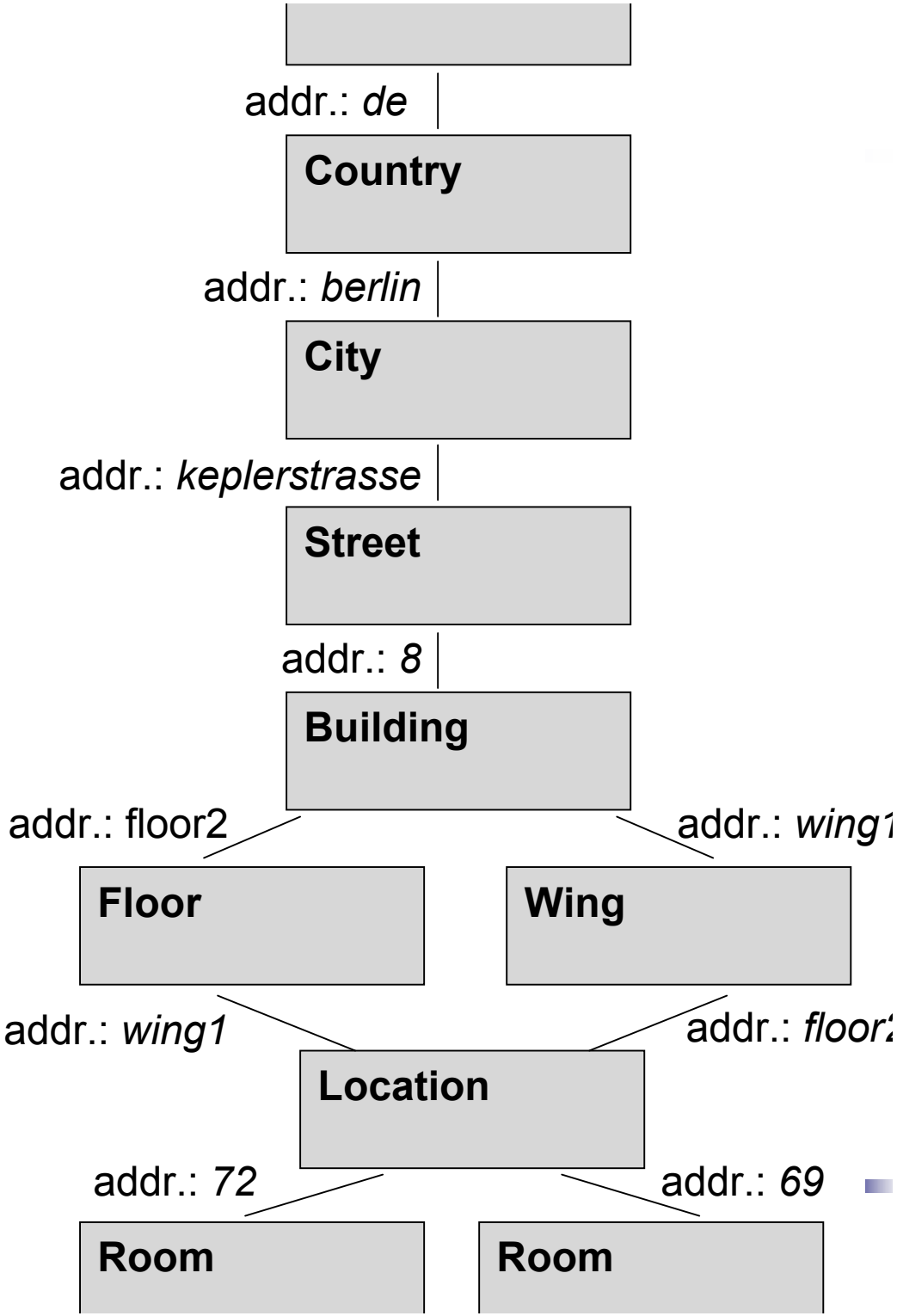
- Set L of symbolic locations
- Partial order $\leq$ defined by the spatial contains relationship, i.e. for two locations $l_1, l_2 \in L$ it holds $l_1 \leq l_2$, iff l_2 contains l_1.
- Hierarchy is a lattice

For every pair $l_1, l_2 \in L$, there exists a supremum $sup(\{l_1, l_2\})$ and an infimum $inf(\{l_1, l_2\})$.

Symbolic Addressing (1)

- Path in lattice determines address:

```
<targetarea>
  <symbol>loc:/de/berlin/
  keplerstrase/8</symbol>
</targetarea>
```

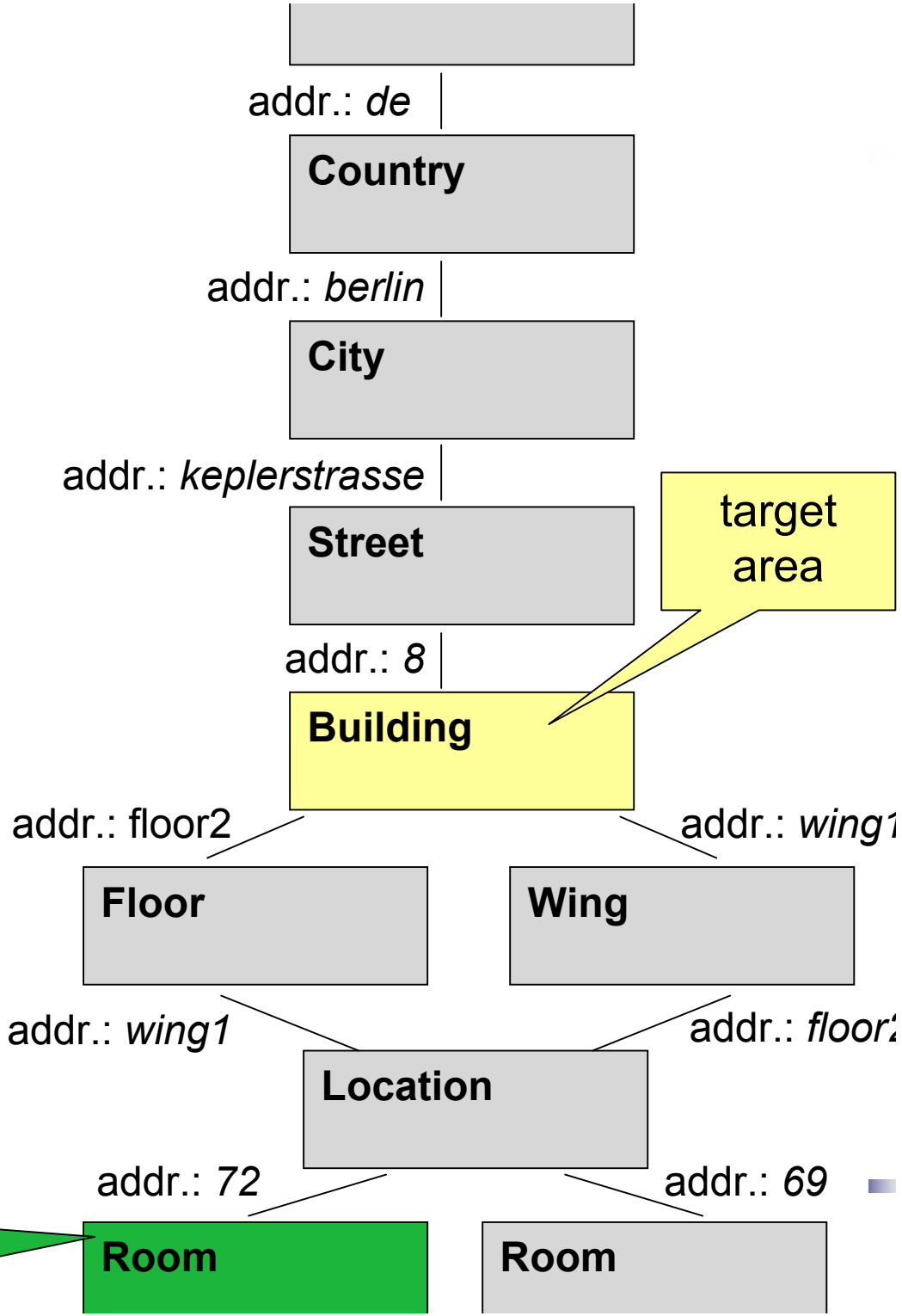


Symbolic Addressing (1)

- Path in lattice determines address:

```
<targetarea>
  <symbol>loc:/de/berlin/
  keplerstrasse/8</symbol>
</targetarea>
```

- Comparison of target area *t* and client area *c*:
  - *intersection* = inf({*t*,*c*})
    - *intersection* = *c* → client inside *t*
    - *intersection* = *nowhere* → client outside *t*

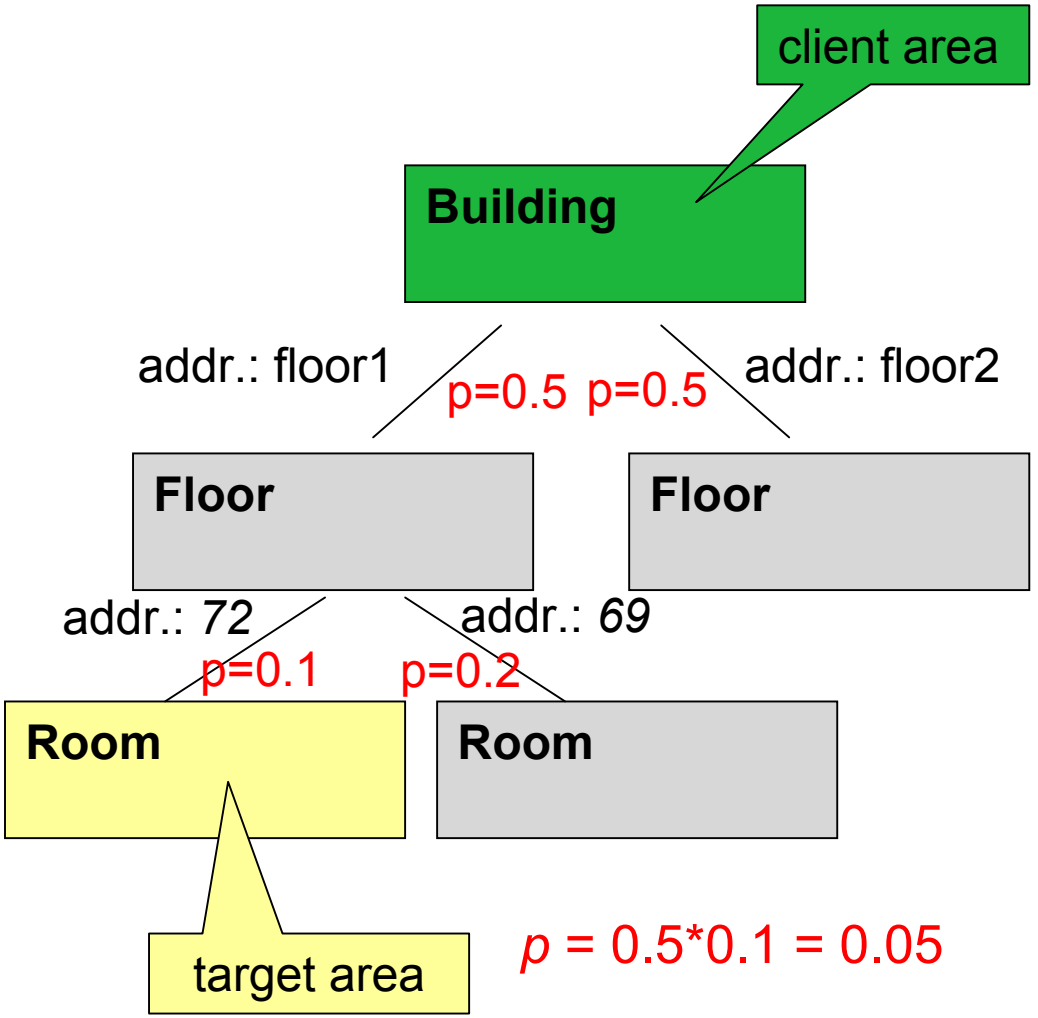


Symbolic Addressing (2)

- Comparison of target area *t* and client area *c*:
  - *intersection* = inf({*t*,*c*})
    - *intersection = c*
      → client inside *t*
    - *intersection = nowhere*
      → client outside *t*
    - *intersection* != *c,nowhere*

  → calculate client's probability *p* for being at *intersection*

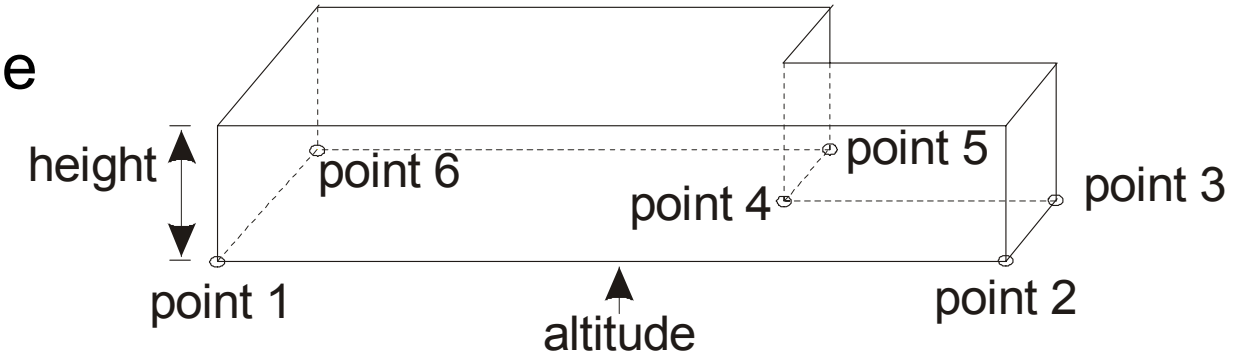
  → deliver message if *p* > *threshold*



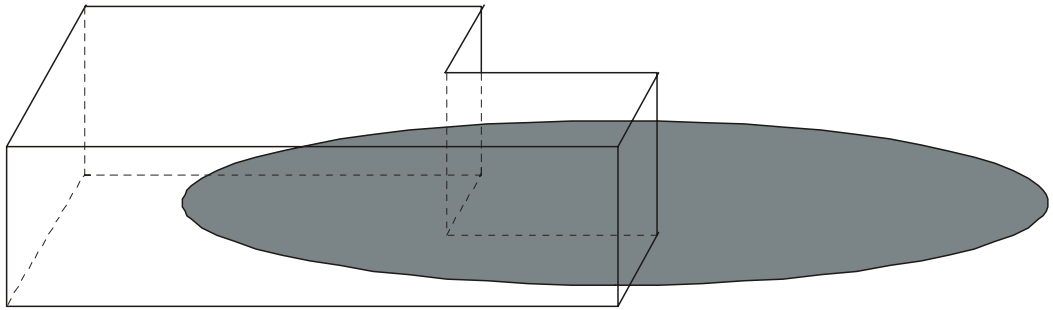
Geometric Addressing

- Geometric figures describe locations:
  - 2D
  - 2.5D (2D + alt. + height)
- Geometric address:

```
<targetarea>
  <polygon>
    <vertex>
      9.126052E
      48.721938N
    </vertex>
    ...
  </polygon>
</targetarea>
```



- Comparison of target area *t* and client area *c:*

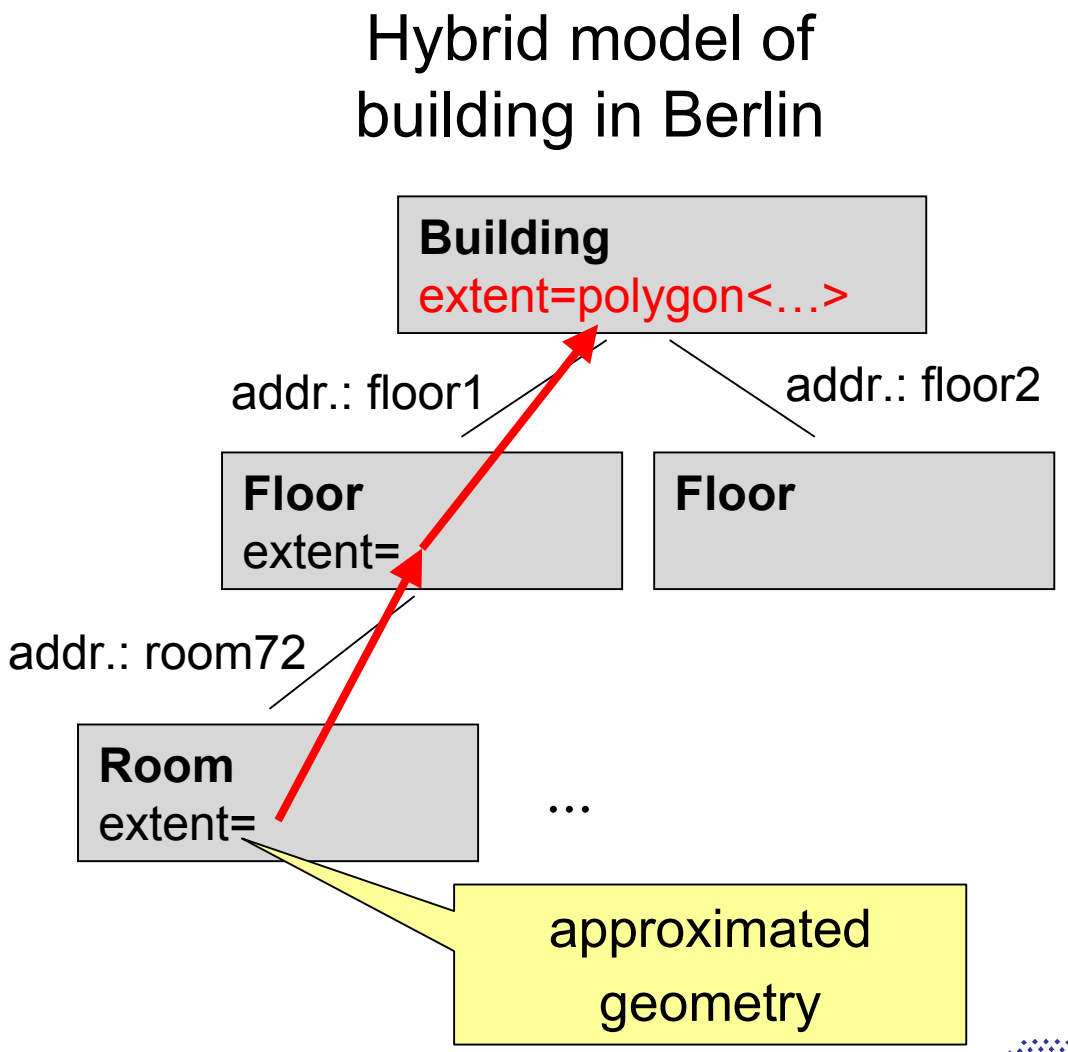


$$p = \frac{A(c \cap t)}{A(c)} \quad \text{with } A(X): \text{area of figure } X$$

Heterogeneous Addressing

- Example
  - Geometrically addressed message to Berlin (WGS84)
  - Symbolic user position: floor1/room72 in a building in Berlin (ActiveBadge)
- **Question**: How to compare these locations?
- **Answer**: Translate one location to other representation.

→ Associate symbolic locations with geometric extent



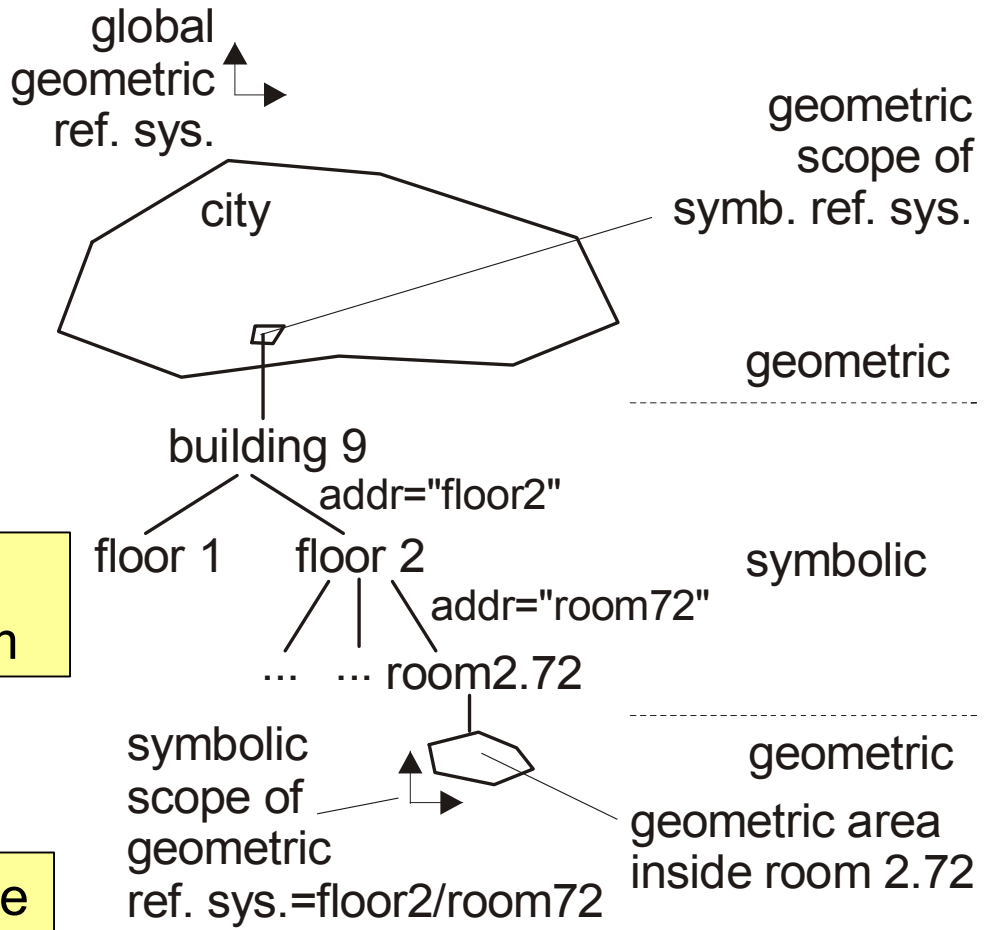
Hybrid Addressing

```
<targetarea>
  <refsys>
    <scope>
      <polygon>...</polygon>
    </scope>
    <name>sys_building9</name>
  </refsys>
  <symbol>
    loc:floor2/room72
  </symbol>
</targetarea>
```

scope of local reference system

Name of local reference system

coordinates relative to local reference system

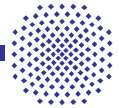


Summary

- Fine-grained geocast requires geometric and symbolic geographic addressing
- Hybrid location model for addressing
  - Hierarchical symbolic locations (lattice-based)
  - Geometric locations: 2, 2.5D
  - Local reference systems

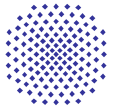
  } associated geometric and symbolic information

- Comparison of target area and client position:
  - Probabilities for inclusion of client position in target area
  - Translation of heterogeneous addresses



Related Work

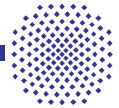
- Wolfgang Kainz and Max J. Egenhofer and Ian Greasley: *Modeling spatial relations and operations with partially ordered sets*. In International Journal of Geographic Information Systems, 7(3), 1993.
- Ulf Leonhardt: *Supporting location-awareness in open distributed systems.* Imperial College London, Department of Computing, PhD thesis, 1998.
- Max J. Egenhofer, Robert D. Franzosa: *Point-set topological spatial relations*, International Journal of Geographical Information Systems 5(2), 1991
- D. A. Randell, A. G. Cohn: *Modelling topological and metrical properties in physical processes*, Proceedings of the First International Conference on the Principles of Knowledge Representation and Reasoning, 1989
- Changhao Jiang and Peter Steenkiste: *A hybrid location model with a computable location identifier for ubiquitous computing*. In Proceedings of the Fourth International Conference on Ubiquitous Computing (UbiComp 2002), Sep. 2002.



Future Work

- Geocast
  - Routing algorithms for fine-grained geocast
  - Geographic multicast
    - Addressing groups of users inside geographic area
  - Realiable geocast

- Nexus in general
  - Integrate symbolic addressing
  - Further extensions of location model, e.g. graph-based approach



Discussion

Thank you very much for your attention!

Further information about location model for geocast:

- Frank Dürr, Kurt Rothermel: *On a location model for fine-grained geocast.* To appear in Proceedings of the Fifth International Conference on Ubiquitous Computing (UbiComp 2003), Oct. 2003
- frank.duerr@informatik.uni-stuttgart.de