Bigraphs and Bigraphical Reactive Systems

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Grand Challenges for Computing Research

1. In Vivo ↔ In Silico

2. ## Science for Global Ubiquitous Computing

3. Memories for Life

4. ## Scalable Ubiquitous Computing Systems

5. The Architecture of Brain and Mind

6. Dependable Systems Evolution

7. Journeys in Non-Classical Computation

Source: `http://www.nesc.ac.uk/esi/events/Grand_Challenges/`

Scenario (1/2)

- Room
  - ♦ Person
    - Wireless head-set
    - Mobile phone
  - ♦ Laptop computer
  - ♦ Telephone

Scenario (2/2)

- The laptop computer and the mobile phone is connected to the internet

- The wireless head-set is connected to the telephone

- The telephone and the mobile phone is con-nected to the phone net-work

Calculi for Mobile Systems

- Ambient-calculus: Focus on location (with local linkage only)

- π-calculus: Focus on linkage

- (Object-)Petri-nets: Focus on location and linkage to near environment

Calculi for Mobile Systems

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…using either of these, it is not easy to describe our scenario…

Remote Linking

- Until now, mobile calculi regard linking as local

- This is not always desirable

- E.g. telephone conversation, internet connections

- We will try to address this

Contents

- Bigraphs

- Bigraphical Reactive Systems (BRS)

- Expressiveness

- Further topics

Bigraphs – Place Graphs (1/2)

- Mobile ambients nicely describe location
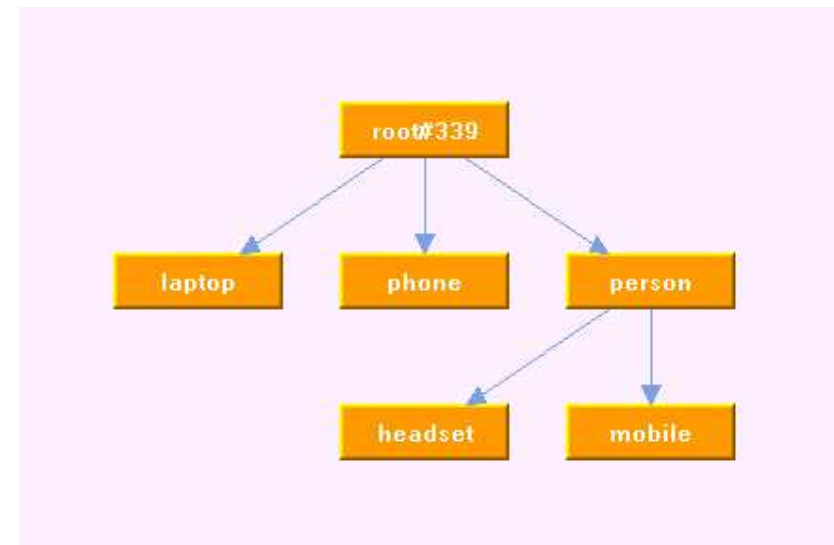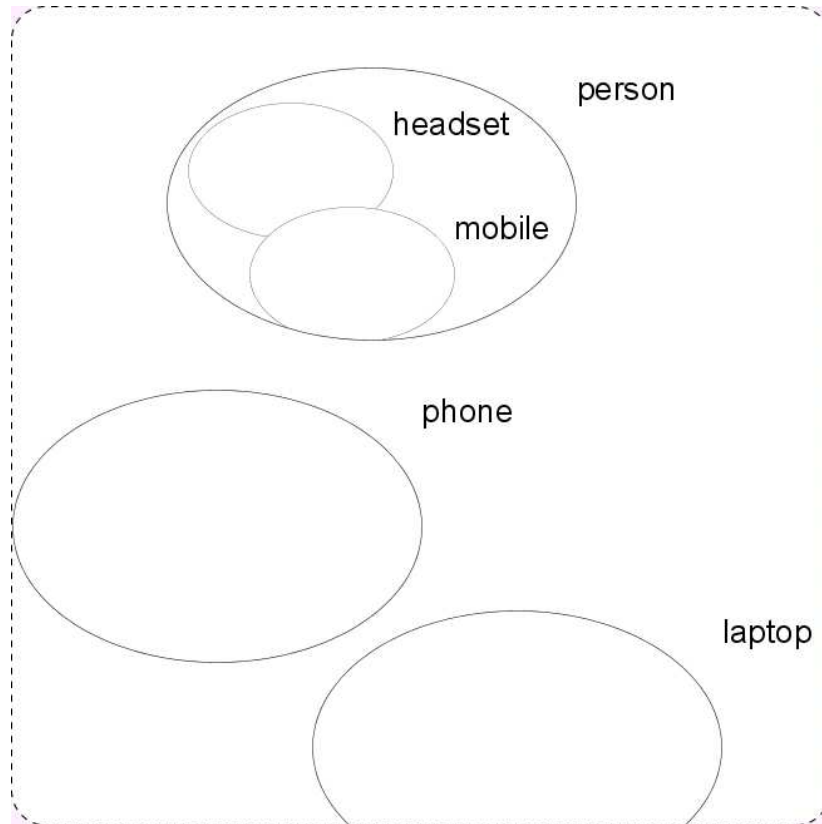- Let us try to describe our scenario...

Bigraphs – Place Graphs (1/2)

- Mobile ambients nicely describe location
- Let us try to describe our scenario...

```
person[ headset[] | mobile[] ] |
        phone[] | laptop[]
```
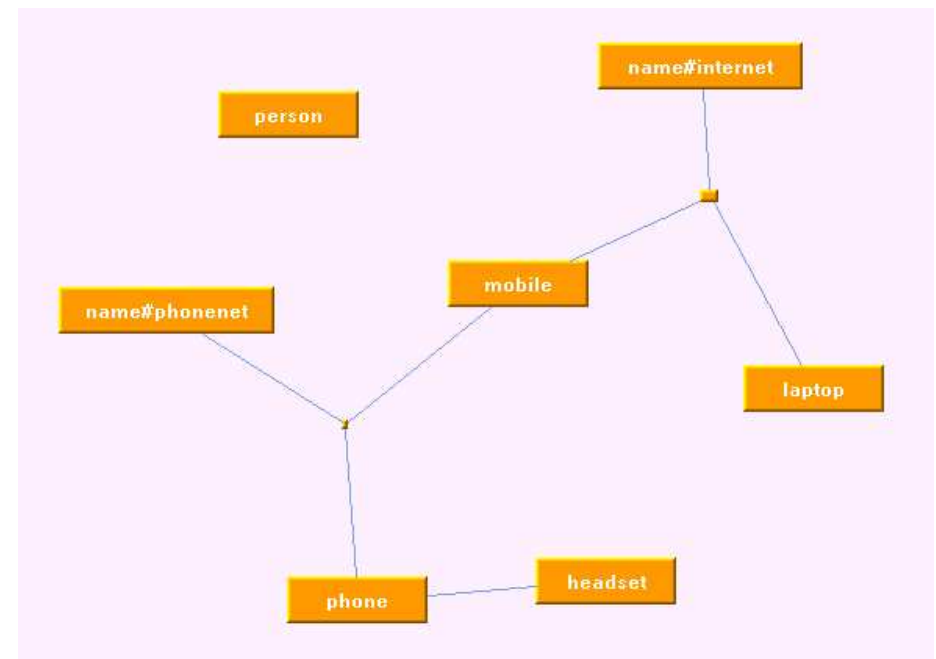
Bigraphs – Place Graphs (2/2)
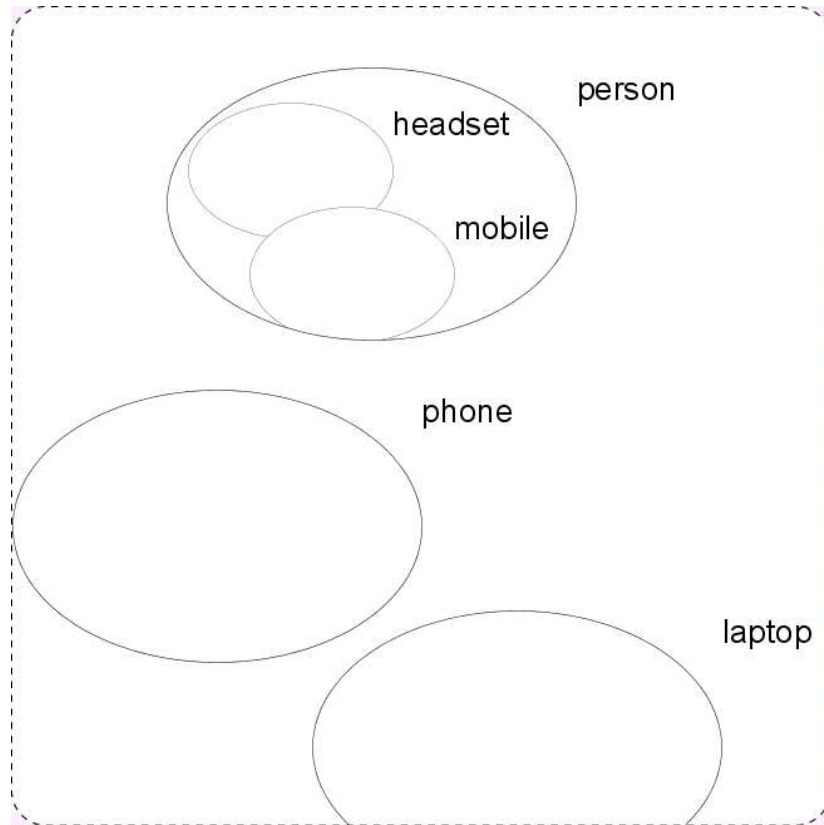
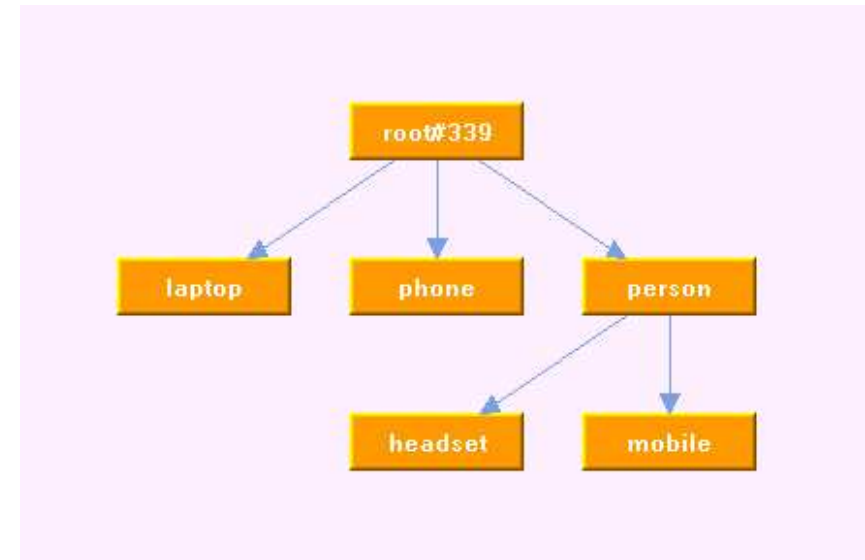# Bigraphs – Place Graphs (2/2)

Bigraphs – Link Graphs

- We can describe
  linkage by
  drawing a graph
  with each entity
  as a node and
  each link as an
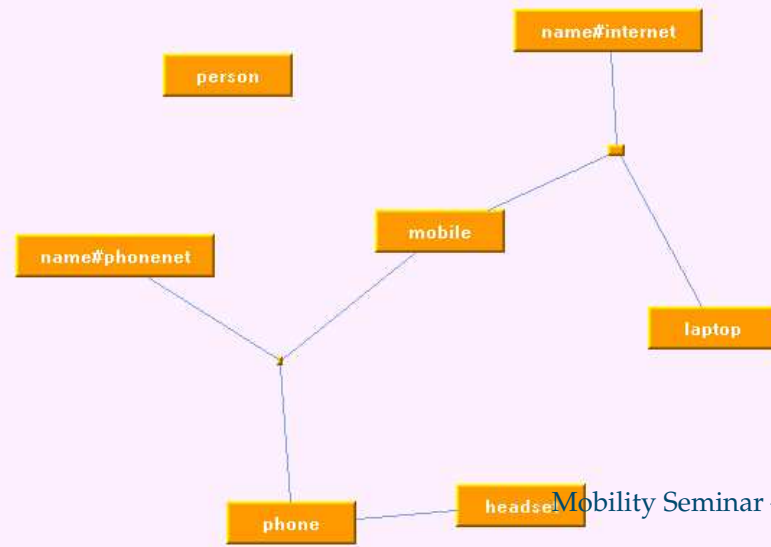 edge
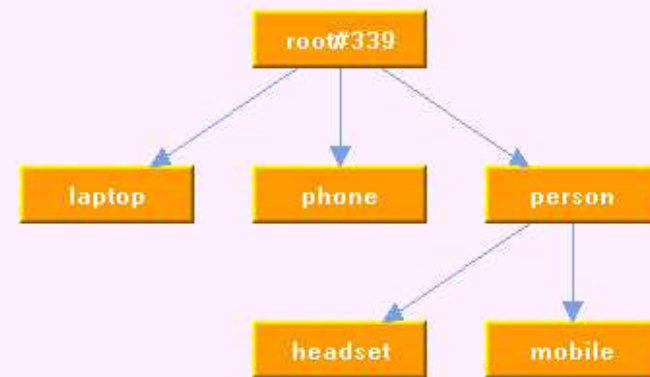
- Compare e.g. to
  network topol-
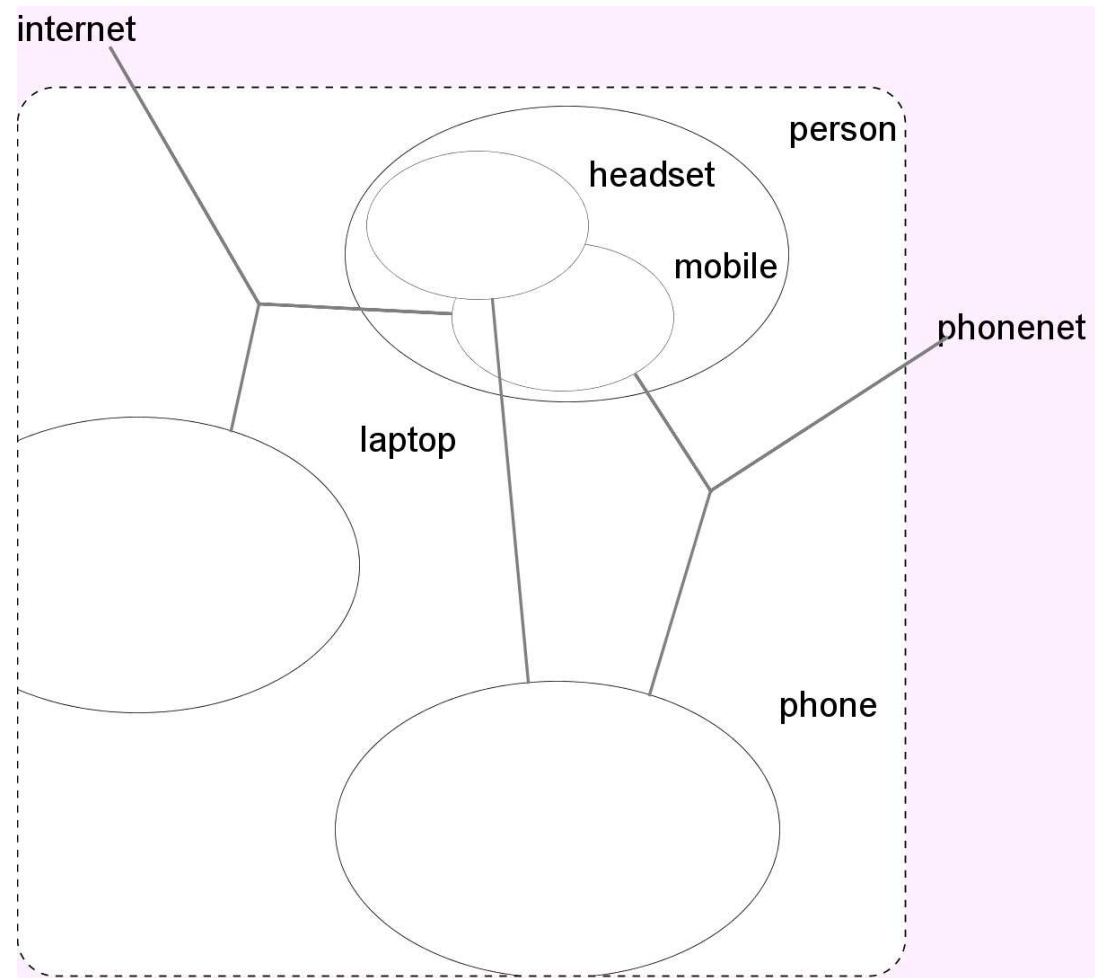 ogy drawings

Bigraphs

- If we take the place graph

Bigraphs

- If we take the place graph
- …and add the links from the link graph

We Obtain the Bigraph...

Bigraphs

- Bigraphs can be used to describe the state of a system, as we have just seen

- …but the world is not static…
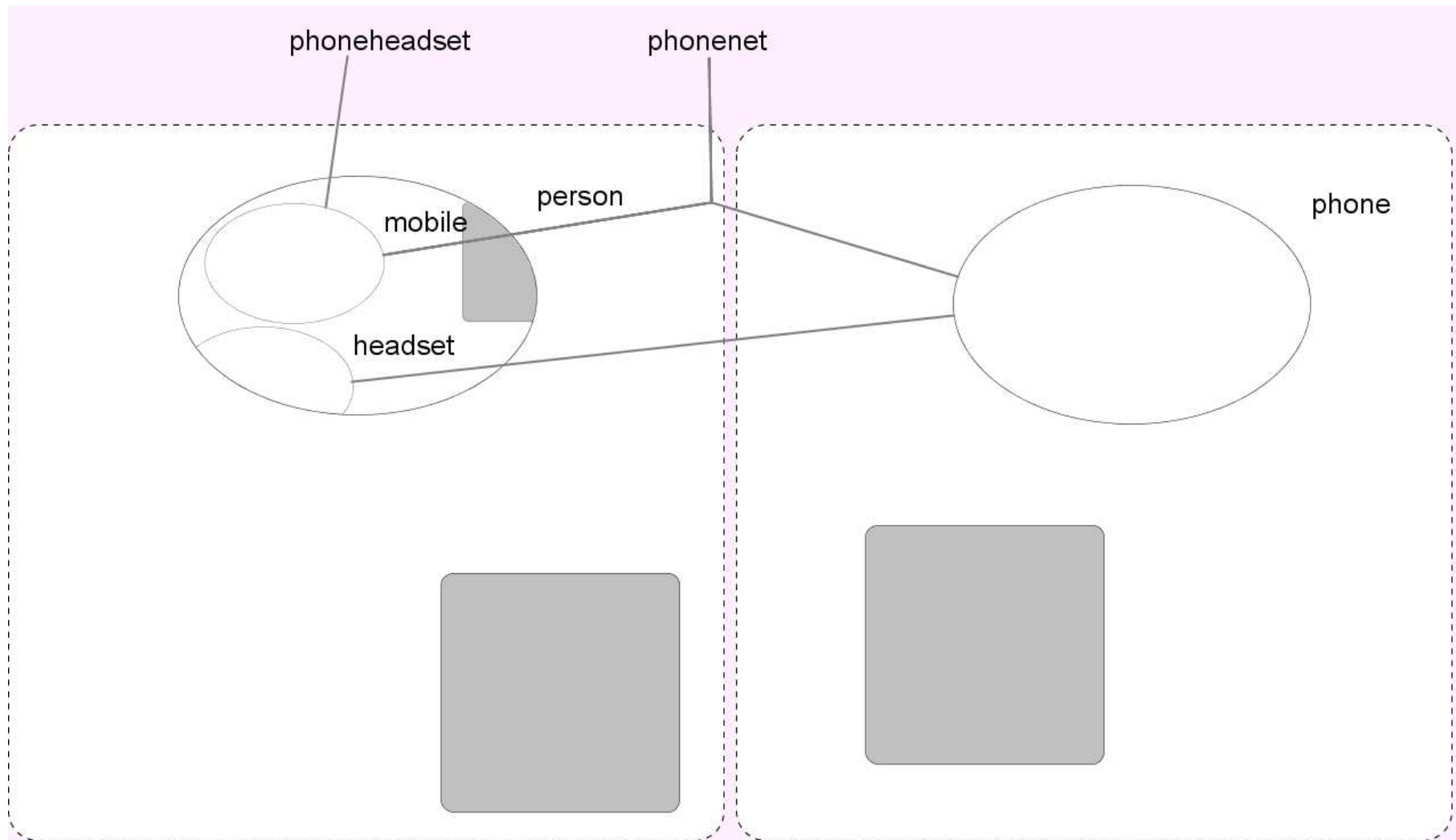
Bigraphical Reactive Systems

Scenario

- The person is talking on his phone using the head-set

- The person leaves the room

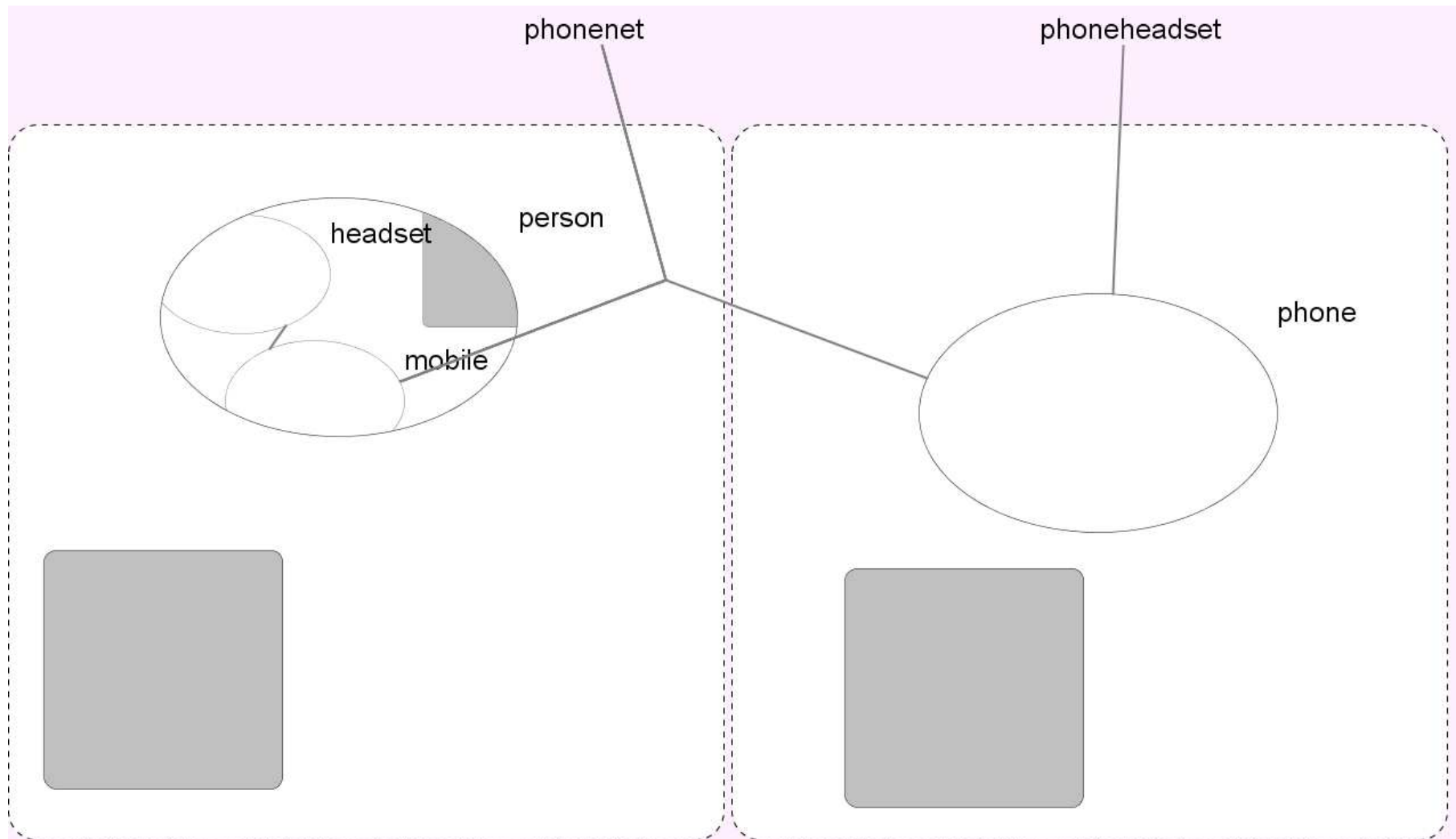- The head-set should hand over to the mobile phone

Reorganisations

- Reorganisations are changes of the configuration

- We describe the situation before the reorganisation (redex)

- ...and the situation after the reorganisation (reactum)
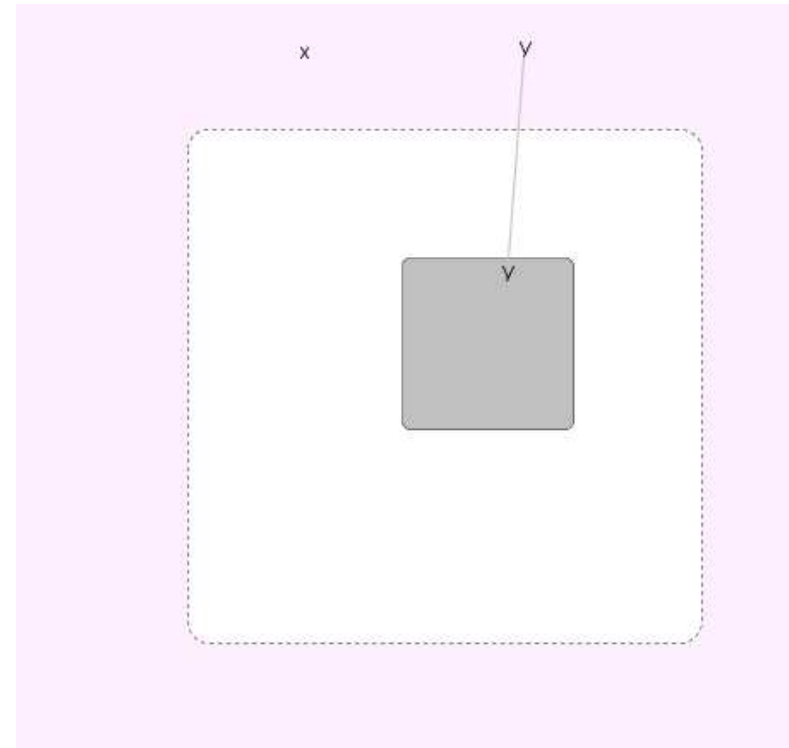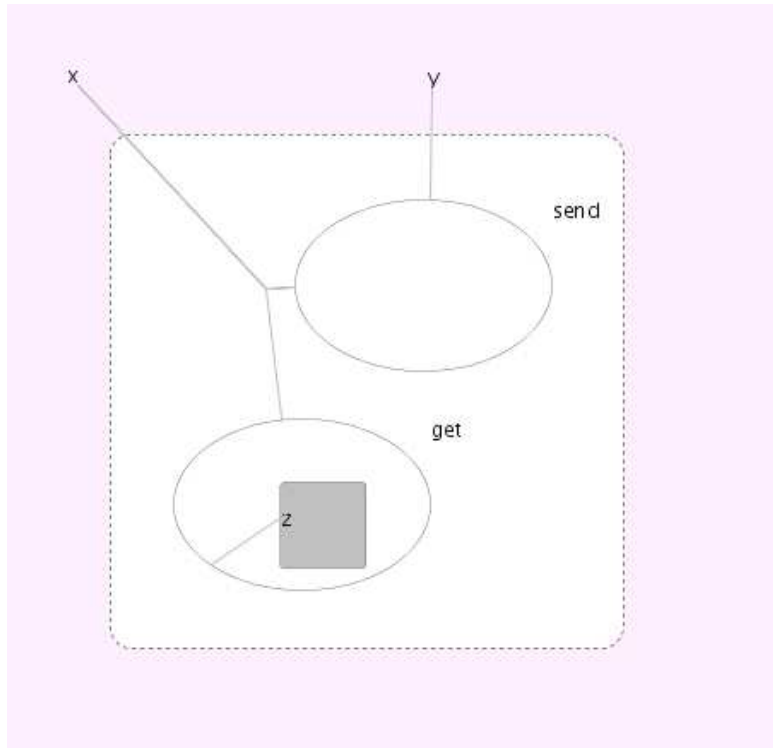
Reorganisations – Redex
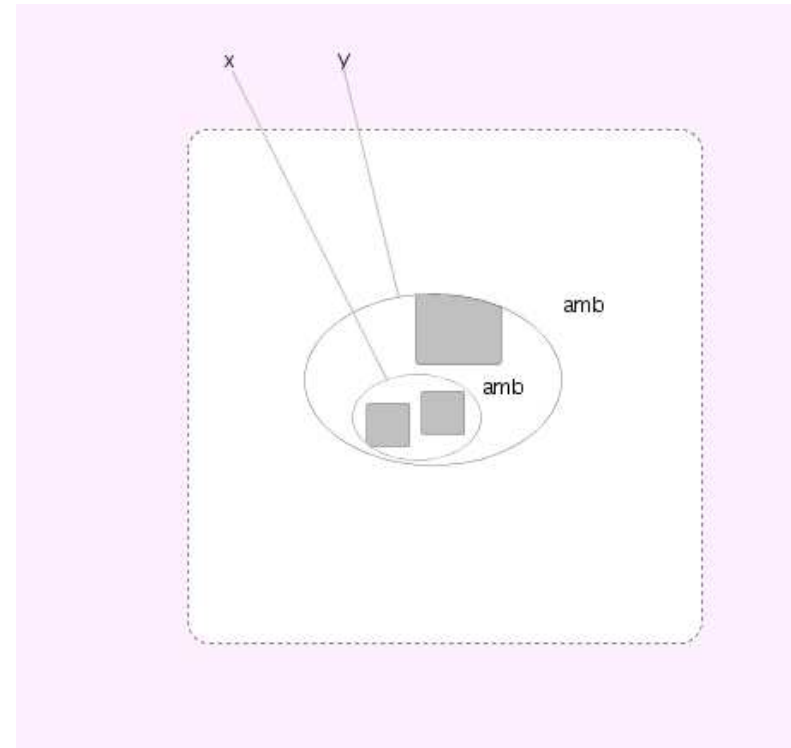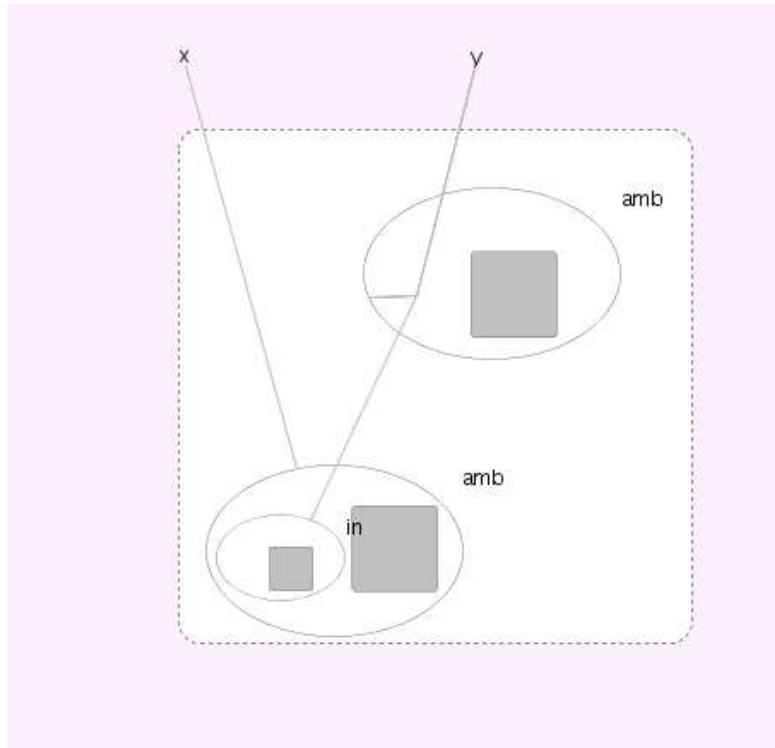
Reorganisations – Reactum

Expressiveness

- A lot of well-known mobile calculi can be expressed using Bigraphical Reactive Systems
  - π-calculus (asynchronous, synchronous)
  - Mobile Ambients
  - Condition-Event Petri nets
  - …

Synchronisation for Async. π

Synchronisation for Ambients

Further Topics

We did not go through...

- Theoretical foundations
- Algebra for bigraphs (and DNF, CNF)
- Labelled transition systems for bigraphs
  $(L \circ a \longrightarrow a' \iff a \longrightarrow^L a')$

More on Bigraphs

Robin Milners homepage:
`http://www.cl.cam.ac.uk/~rm135/`

TIN-CPN:
`http://wiki.daimi.au.dk/tincpn/`

Conclusions

- Bigraphs can describe *location* and *linking*

- Bigraphical Reactive Systems makes it easy to declaratively and intuitively describe system reconfigurations

- Bigraphical Reactive Systems are (at least) as powerfull as other well-known calculi

- Open and very interesting topic!