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Ubiquitous Computing...
infrastructure....

.. last time I go anywhere
without a laptopand a
gigabyte of powerpoint...

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Ubiquitous middleware

What's the research problem

- Scale
- Reliability
- Heterogeneity
- Power
- Availability
- Robustness
- Mobility
- Disconnection
- Security and privacy
- Device or software
- Sensors
- Interfaces and interactions

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Three Challenges of Ubiquitous Middleware

- Developing middleware in ubiquitous computing environments
- How the infrastructure presents its self to those who inhabit ubiquitous computing environments
- How the infrastructure is used and adapted and supports the evolution of those environments

Developing Ubiquitous Middleware

- The key issue is that ubiquitous computing needs to exist in the everyday world
- It is situated in this world by the people who inhabit the world
- It needs to be understood manipulated and altered by members of the real world
 - How do we make the infrastructure visible to allow it to be understood
 - How do we provide facilities to allow it to be changed.

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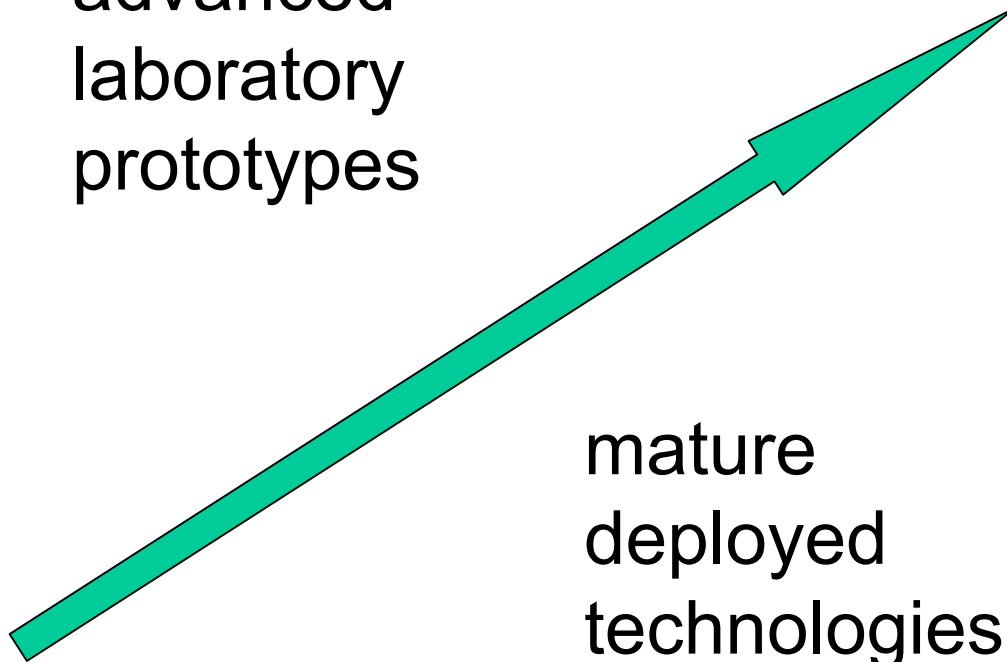
UbiComp and middleware

The difficulty for ubiComp is that the infrastructure research needs to take place within the **context of use**

How do we focus on issues arising when infrastructures need to find a place within the real world alongside competing paradigms and approaches

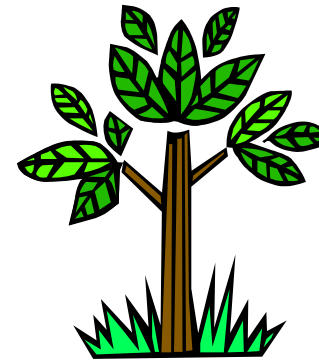
in the wild...

advanced
laboratory
prototypes



mature
deployed
technologies

experiences



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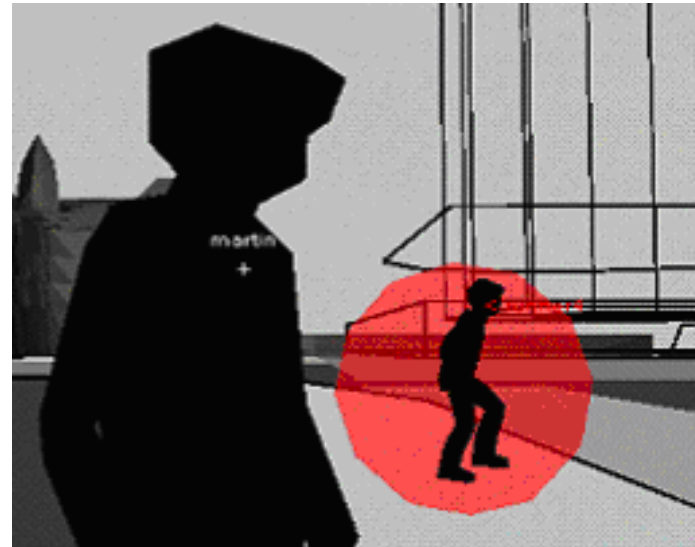
The infrastructure dilemma

The need for **real world use** to inform future infrastructure presents a dilemma – we need to outline infrastructural requirements *before* such a platform is available for use

One way to do this is to deploy advanced research infrastructure before users in the form of **installations**

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Can You See Me Now?



- Online players chased across a virtual city by 3 runners on the actual city streets
- Staged in Sheffield, Rotterdam and Oldenberg

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Seeing the infrastructure

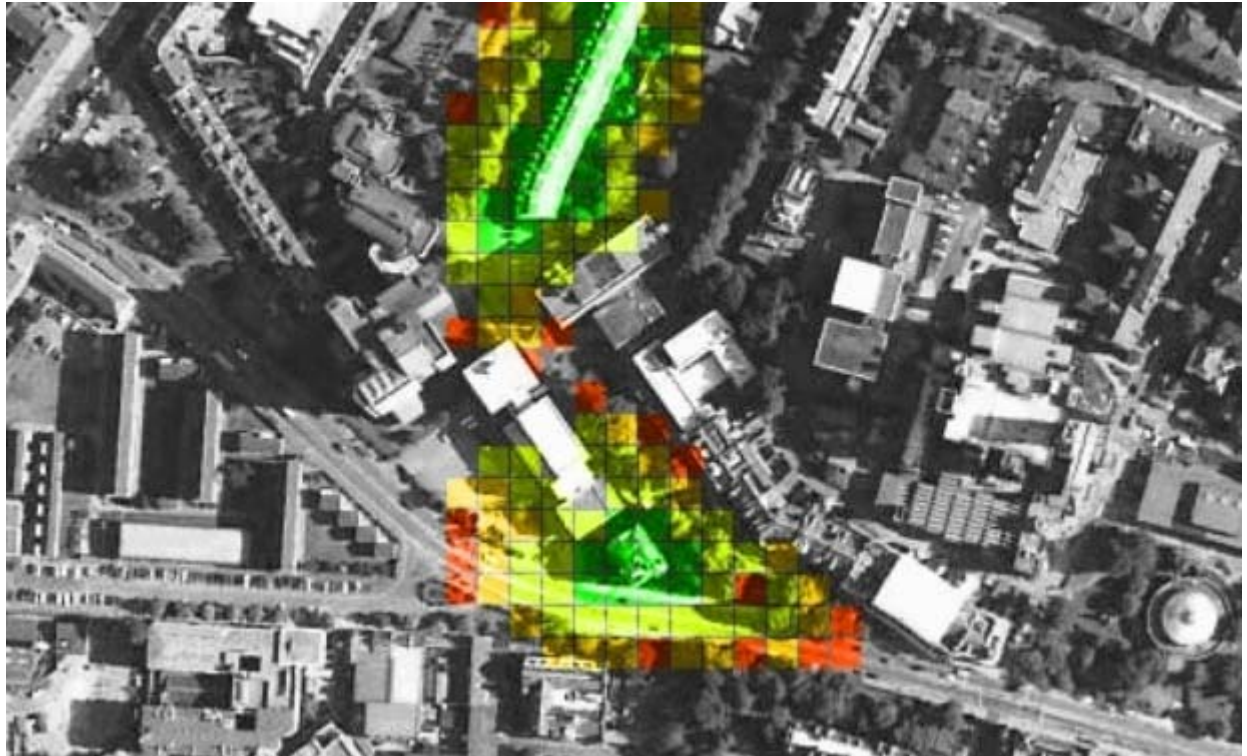
- For ubiquitous computing the underlying infrastructure becomes something that is reasoned about
- Can you see me now
 - the runners interacted with the infrastructure.
 - They exploited wavelan shadows
 - They exploited good areas of GPS coverage
 - They had to deal with the uncertainty of position
 - They made judgement based on approximates
- But the infrastructure does not show these things to let them do this

Present the infrastructure

- In addition to handling the host of other systems issues ..
- how is the infrastructure made available to users
- Need to move beyond the traditional design approach of strict transparency
 - What are the mechanisms for revealing the workings of the infrastructure ..

Revealing the underlying seams

- So they are understood by the inhabitants
- In order that the effects on their interaction can be reasoned about



An overlaid map of 802.11

Our world is open to continual change

Our world is always changing and a large number of different people are involved with **Inhabitants** having a central role.

However, the presumption is that for **distributed infrastructures** systems engineers undertake

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Need to reduce the cost of
change ...

Shift in focus on target users

from **developer**

through **experience builder**

towards **inhabitant**

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Step 1.. from programming to content creation....

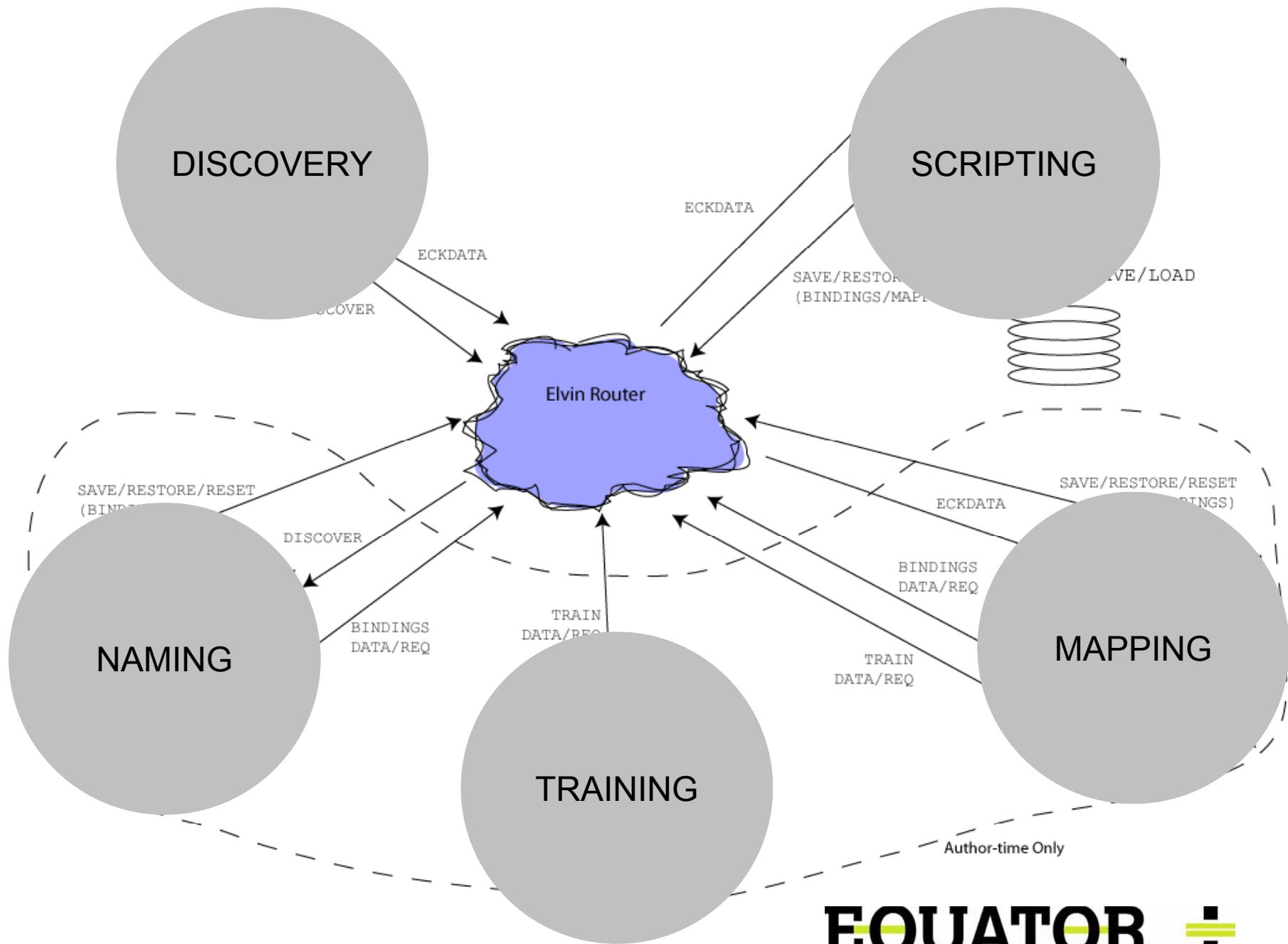
- Most Infrastructure work is aimed at ease of programming
- Content creation involves considerable shared effort between designers and programmers
- Need to empower designers to build their own distributed mixed reality experiences
 - c.f. Distributed Phidgets (Greenberg, 2001)/ EZIO
- Enable content creator and designers (and others) who have limited programming skills to build experiences

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Approach

Use off the shelf components to build a prototype in the language of the content creators

- Uses *Director* as a design-interface
 - Unprincipled, but well accepted by designers
- Uses *Lightweight* sensors as inputs
 - At present Cyberjacket and Smart-Its
- Uses *Elvin* to route messages between components



Extending Director

- Sensors appear as cast members through 'Xtra'
 - Bindery displays new sensor (uses XML database to find icon, default name, behaviour)
 - Designer can give the sensor a useful name
 - This name can be used in Director's Lingo script

```
on location x, y
    ...
end
```
 - Binding is saved and remembered with the Director movie

Programming by Example

- Can be tiresome to work with locations or other sensors as numbers (`if x<10 and y<10 then`)
- Train the system *by example*
- Paintings of Picasso, Rembrandt, van Gogh
- System asks you to go to each location (training)
- Optionally,
 - Can introduce empty space between classified areas
 - Or hysteresis to stabilise classifications
- Names can again be used in Director:
`on Picasso`
...

Moving towards the inhabitant

- People do not describe themselves in terms of lingo
- What are the appropriate ways to represent the infrastructure and allow people to amend this
- Need to find a set of principles to allow people to change and describe their environment
- Need to find a way of reasoning about these changes to prevent catastrophe

research challenges

The biggest issue for me is that ubiquitous computing moves the middleware much closer to the users.

- Developing middleware “in the wild” that can be deployed and understood in practice
- Reaching into the infrastructure and deciding how it presents itself to support practical reasoning
- Supporting evolution and repurposing by significantly reducing the the cost of creating ubiquitous environments

.. and open questions

- We all live in an incomplete and messy world.. because we can reason about it and modify it
- Our existing design principles are failing ubicomp .. because they embody a separation between those who build and those who inhabit
- How will we represent ubiquitous systems infrastructure and reason about them
 - For the systems developer
 - For the content creator
 - For those who will live in these ubiquitous computing environments.
- But how do we prevent chaos..
 - What will be the systems theories of the future
 - How close will these be to the activities of users