A SCIENTIFIC HORIZON FOR COMPUTING

Robin Milner, WCC 2004

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- **Grand Challenges**: what and why?

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- **Mounting** this Challenge

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- **Mounting** this Challenge
- Some **beginnings**

WHAT IS A GRAND CHALLENGE?

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- . . . with clear **goals**, clear **failure criteria** . . .
- and **worldwide participation**.

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- The community examines and adopts **long-term goals** . . .
- . . . from **within the science**, not outside it.
- Thus to develop and refine a **portfolio of proposals** . . .
- . . . showing the public (and funders) **what we aspire to**.

THE UK GRAND CHALLENGE PROPOSALS

1 IVIS: In Vivo ⇔ In Silico

2 Science for Global Ubiquitous Computing

3 Memories for Life

4 Scalable Ubiquitous Computing Systems

5 Architecture for Brain and Mind

6 Dependable Systems Evolution

7 Journeys in Non-Classical Computation

SCIENCE FOR GLOBAL UBIQUITOUS COMPUTING

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- Shall we understand it?

UNDERSTANDING and BUILDING

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- For **Ubiquity??** Separation will lead to *stagnation or worse.*

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- In the software market speed of delivery is paramount:
  Software houses cannot afford time to deploy theories

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- *To develop an informatic science whose* **concepts**, **calculi**, **theories** *and automated* **tools** *allow descriptive and predictive analysis of the GUC at each level of* **abstraction**

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www.nesc.ac.uk/esi/events/
Grand_Challenges/proposals/Ubiq.pdf

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An *ideal* goal? But no argument limits the degree of possible success!

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. . . *and* **what more?**

GUC RESEARCH: THREE KINDS OF PROJECT

Experimental Applications: *Collaborate* with designers of specific systems.

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A Theoretical Hierarchy: . . .

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Why do we need models at many abstraction levels?

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Lower levels: **structural dynamics, coding**

- **locality refinement; programming; routing; assembly code: . . .**

- *many lower levels* – e.g. **higher-level language** compiled to **code**, **action-at-distance** realised by **explicit message routing**

THINGS TO THINK ABOUT . . .

THINGS TO THINK ABOUT . . . TODAY!

A BEGINNING: STRUCTURAL DYNAMICS

- GUC systems reconfigure both their *topography* and their *connectivity*, both physical and virtual.

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- Then extend to a *stochastic* model with *continuous time and space* . . .

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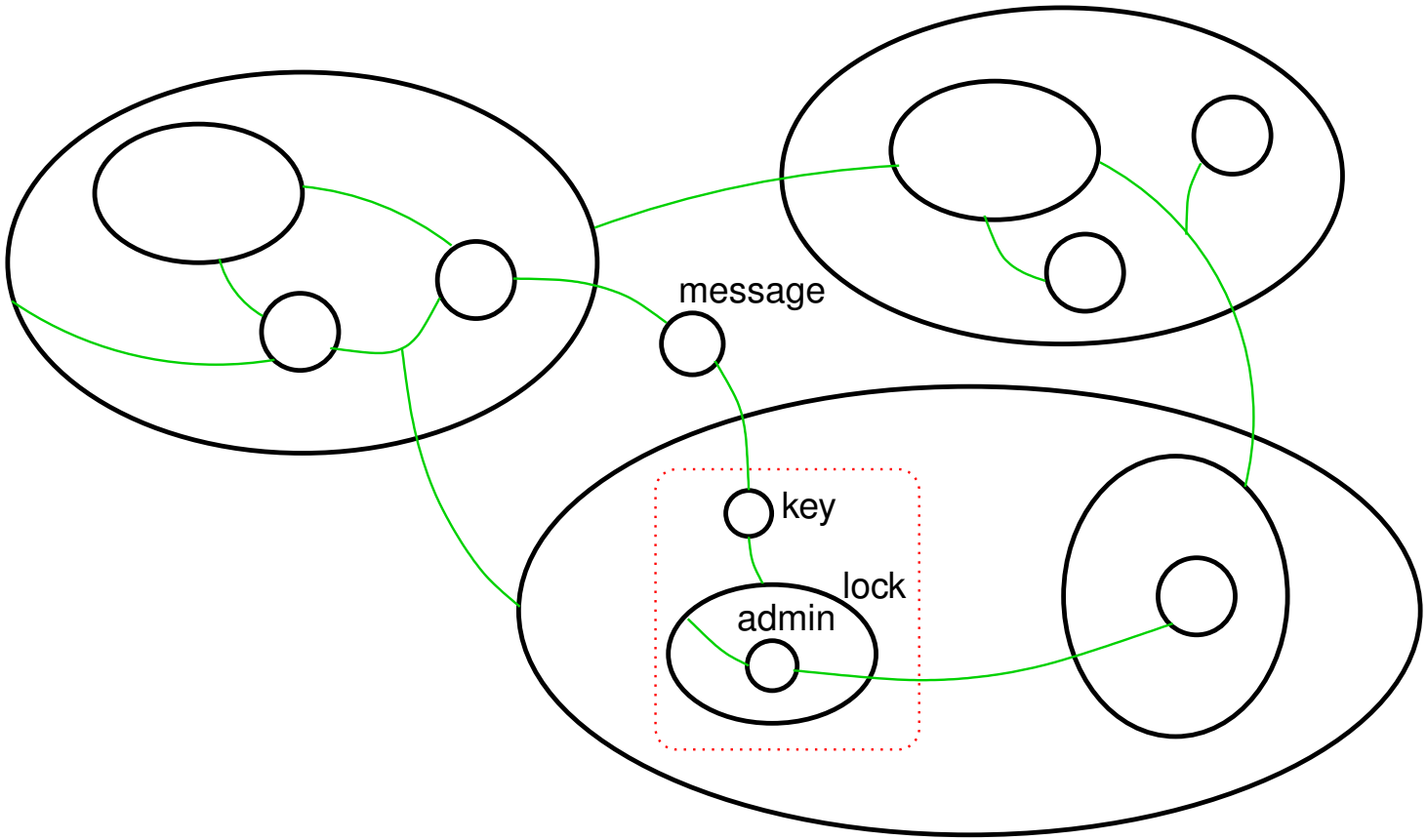
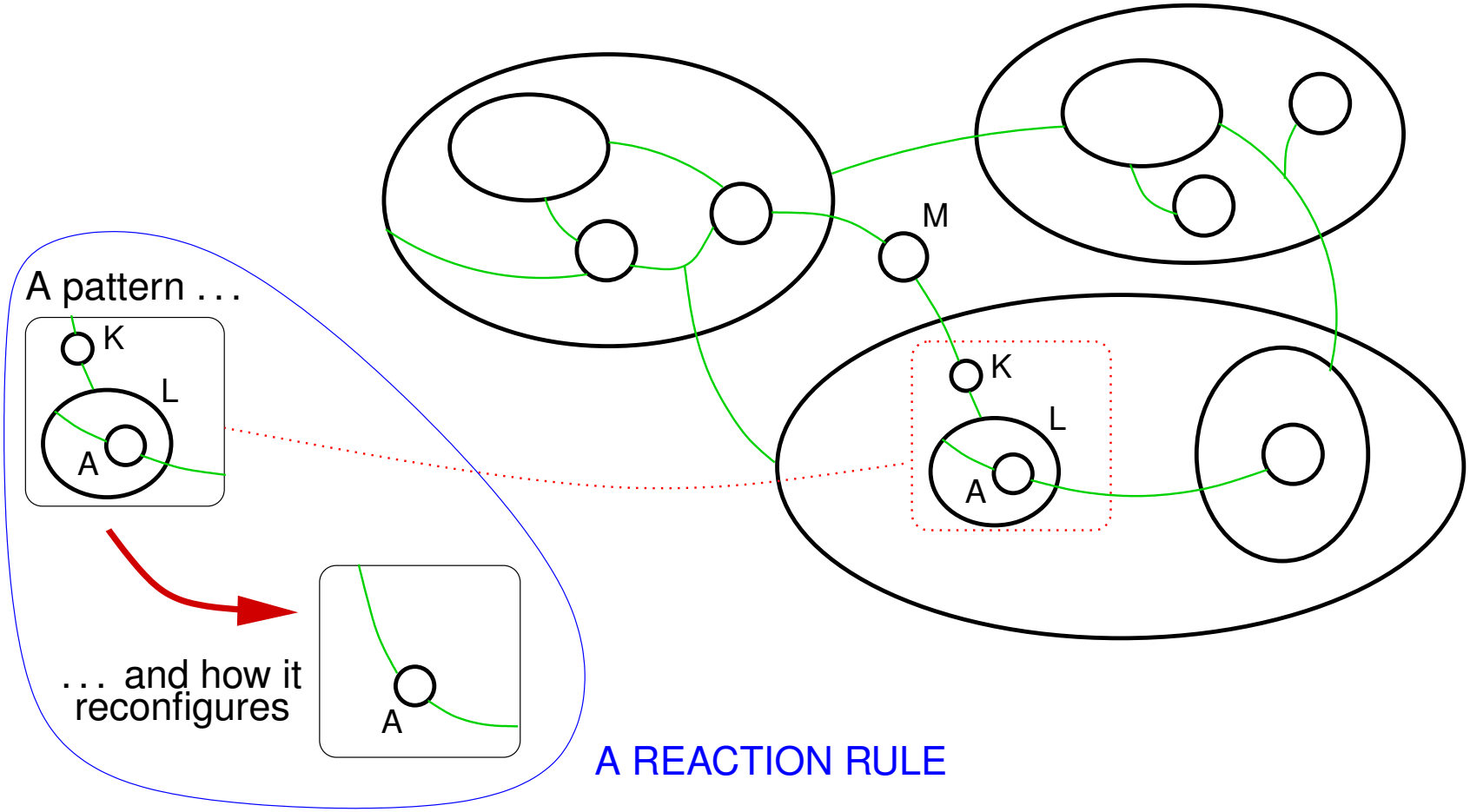
- . . . so try using **bigraphs**, which generalise these.
- Then extend to a *stochastic* model with *continuous time and space* . . .
- . . . both for *modelling* and for *programming*.

A TYPICAL BIGRAPH

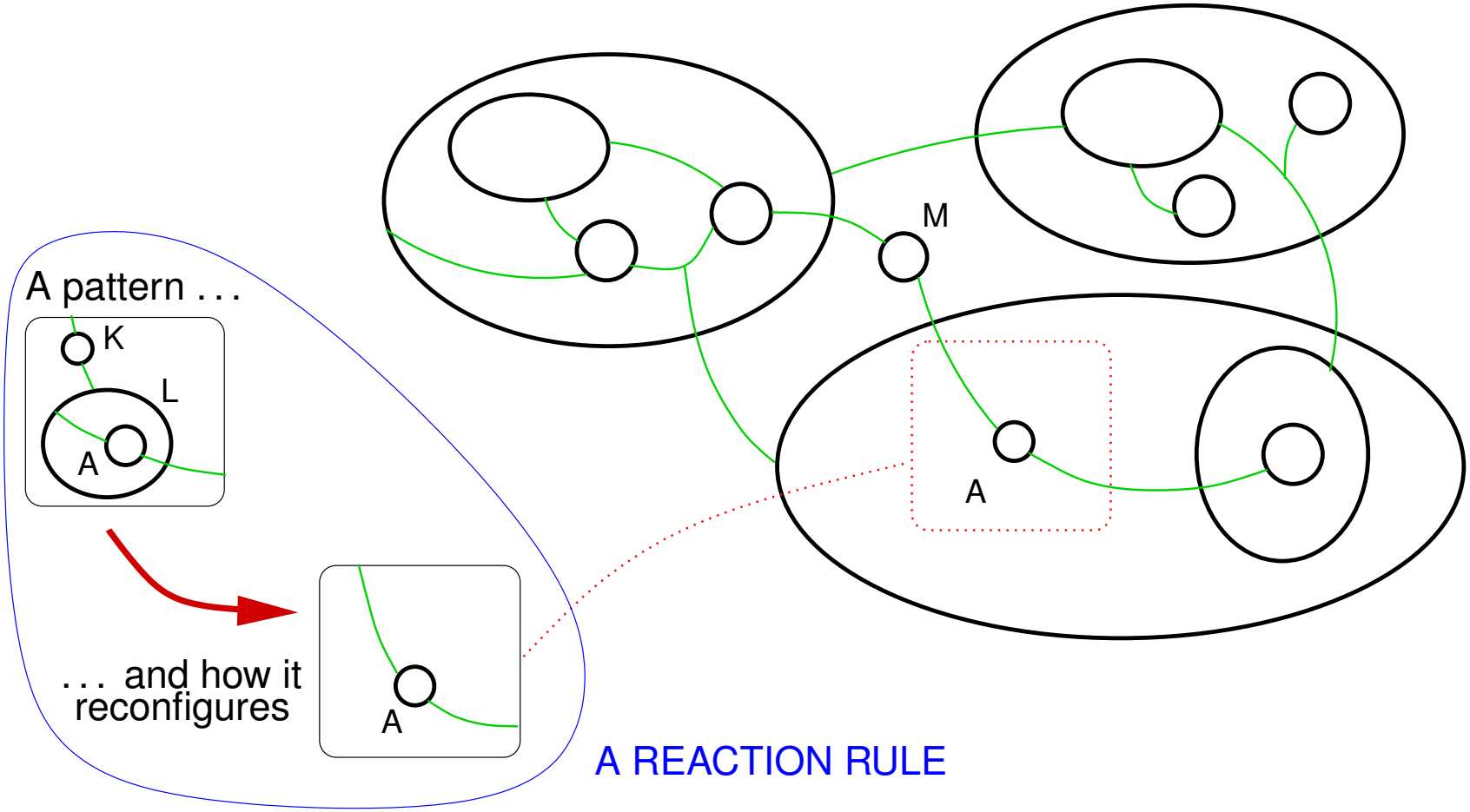


HOW A SYSTEM MAY RECONFIGURE . . . . . .



A REACTION RULE

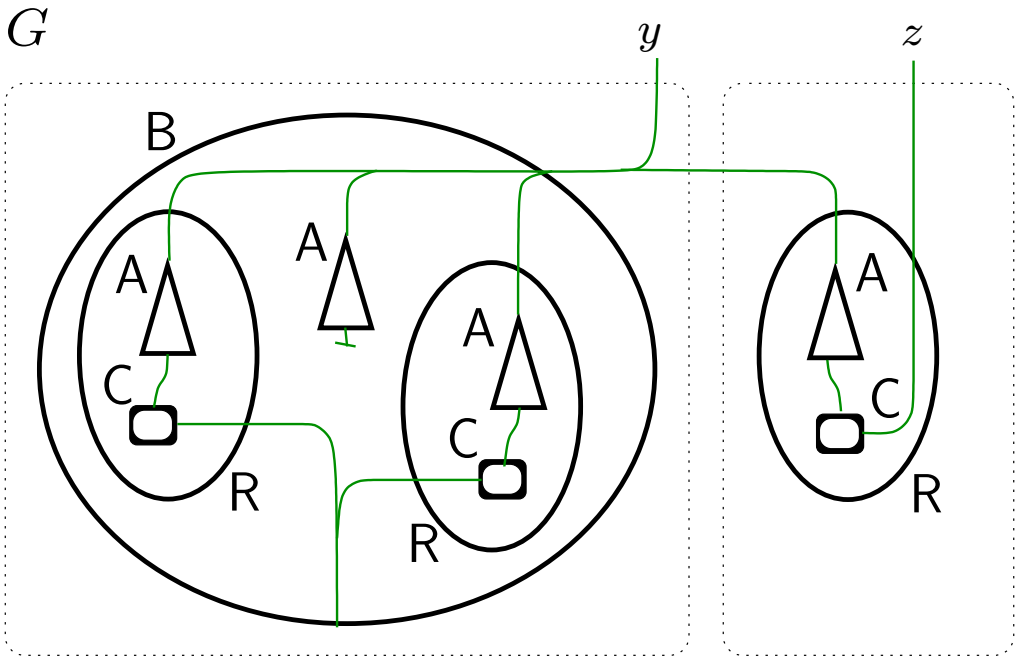
. . . . . AND THE NEW CONFIGURATION



INTERACTIONS IN A BUILT ENVIRONMENT (1)

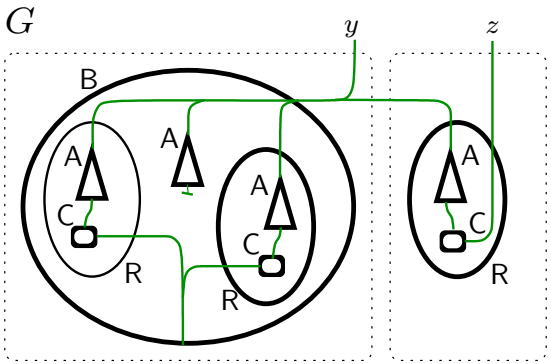
A bigraph G with two regions, representing a conference call

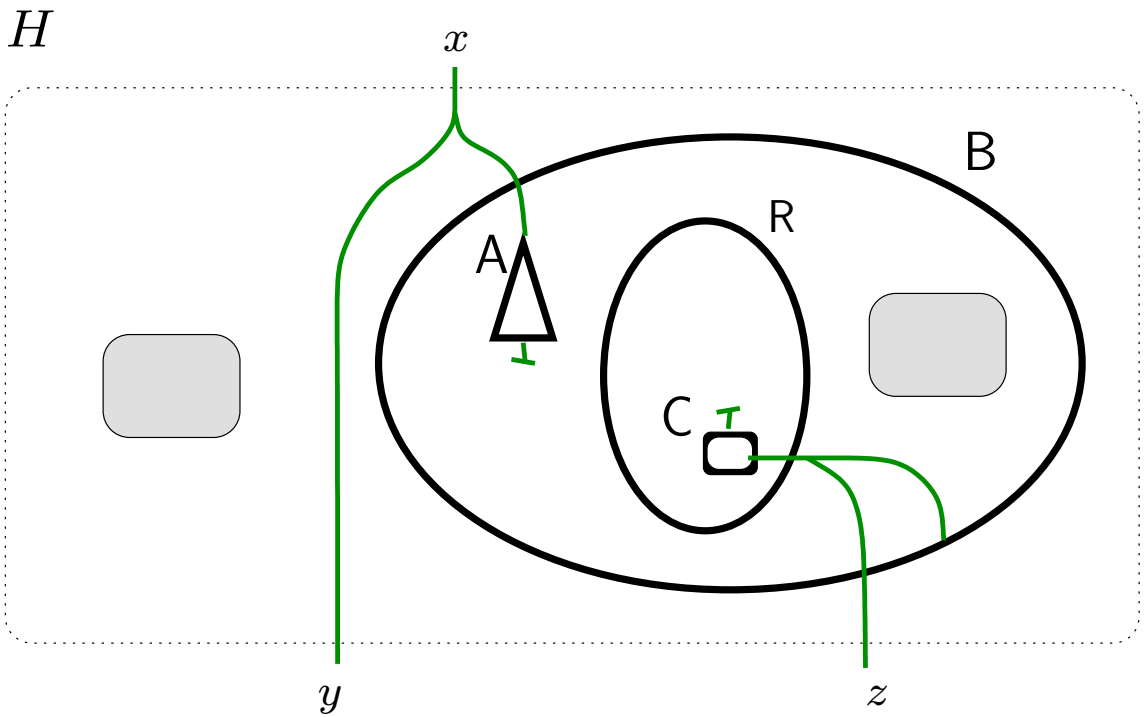
- B BUILDING
- R ROOM
- A AGENT
- C COMPUTER



INTERACTIONS IN A BUILT ENVIRONMENT (2)

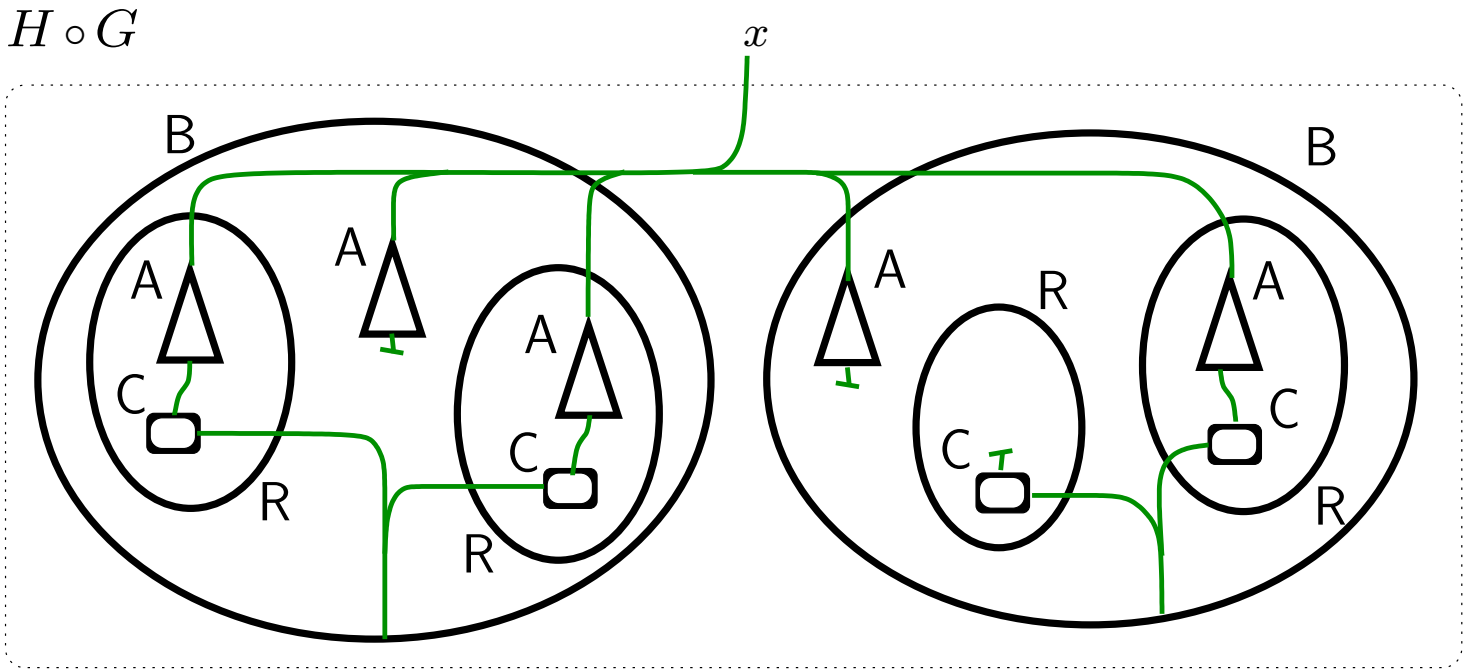
A host environment H, which G may inhabit





INTERACTIONS IN A BUILT ENVIRONMENT (3)

The larger environment, $H \circ G$.



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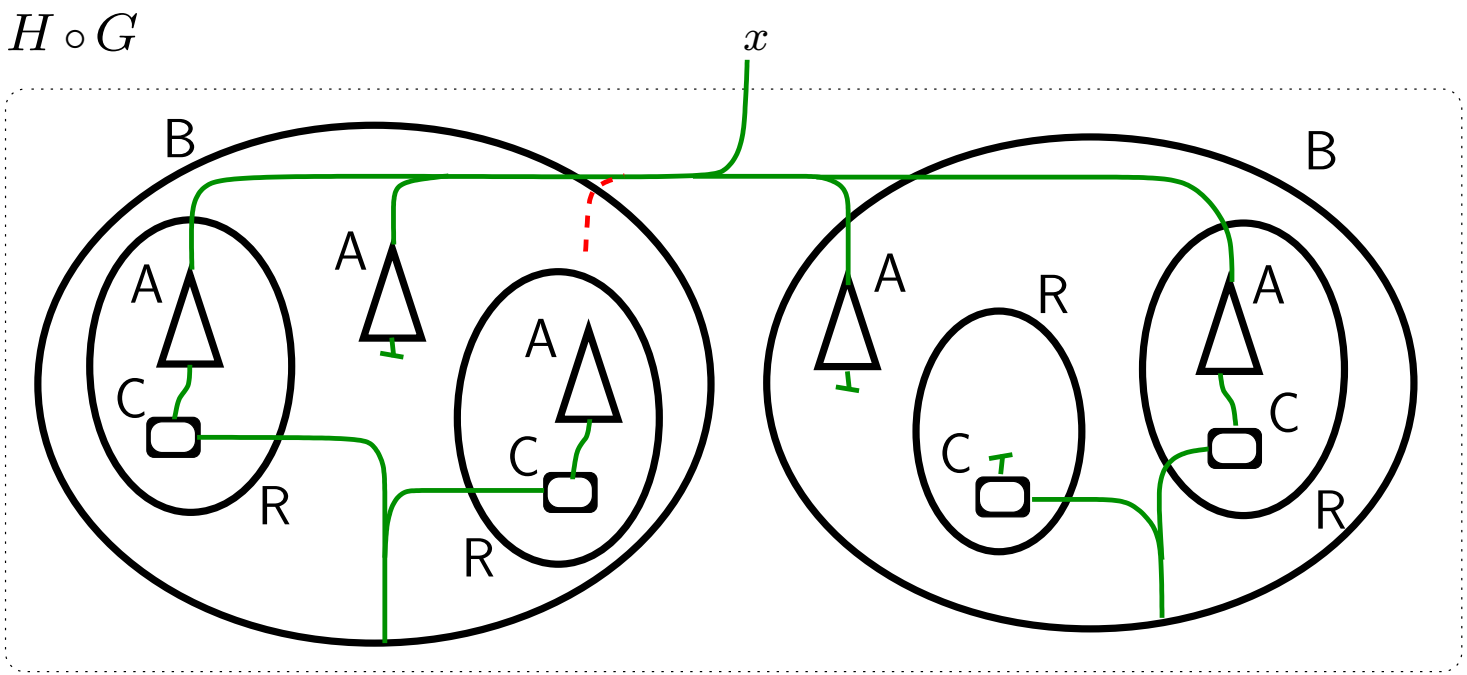
One agent leaves the call!

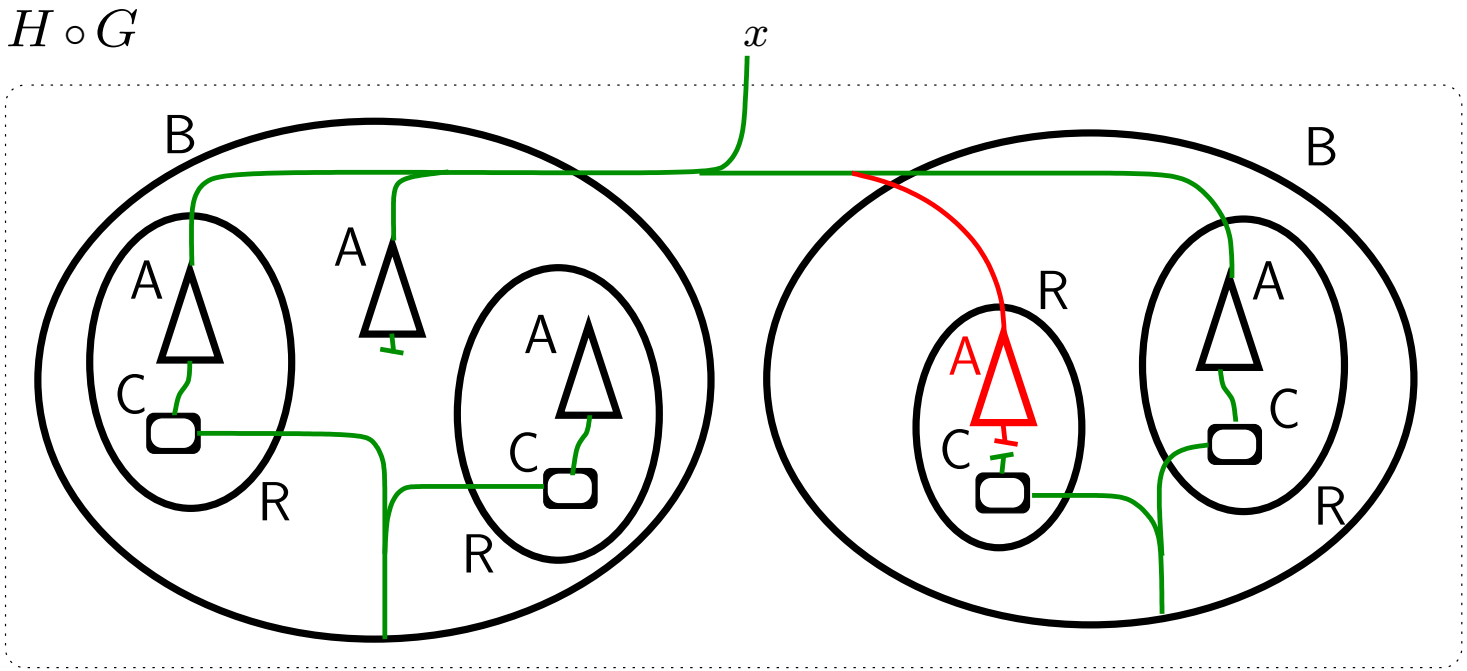


INTERACTIONS IN A BUILT ENVIRONMENT (3)

The larger environment, $H \circ G$.

One agent leaves the call!

Another moves into a room!



CONCLUSION

- The **challenge** is to devise computational *theories* for GUC system alongside the *engineering* of those systems. . .

AND

- . . . the **sub-challenge** is to establish dialogue between the *theorists* and the *engineers*.

FACTS on the GUC proposal

www.nesc.ac.uk/esi/events/Grand_Challenges/

Two linked Grand Challenge proposals. The website contains their proposals, and runs a discussion group. Please join and participate!

- **Science for the Global Ubiquitous Computer**
  moderated by Marta Kwiatkowska and Vladi Sassone.

- **Scalable Ubiquitous Computing Systems**
  moderated by Jon Crowcroft.

- Both these GCs subscribe to **UbiNet**, a UK network on all aspects of ubiquitous computing, at **www-dse.doc.ic.ac.uk/Projects/UbiNet/** .

- Also linked to an FET initiative GC2, **Building the Case for Global Computing**, for Framework 6 of the EC. **www.cogs.susx.ac.uk/users/vs/gc2/gc2.pdf** .