ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Seminar in Distributed Computing

The Metanet

The future of networks?

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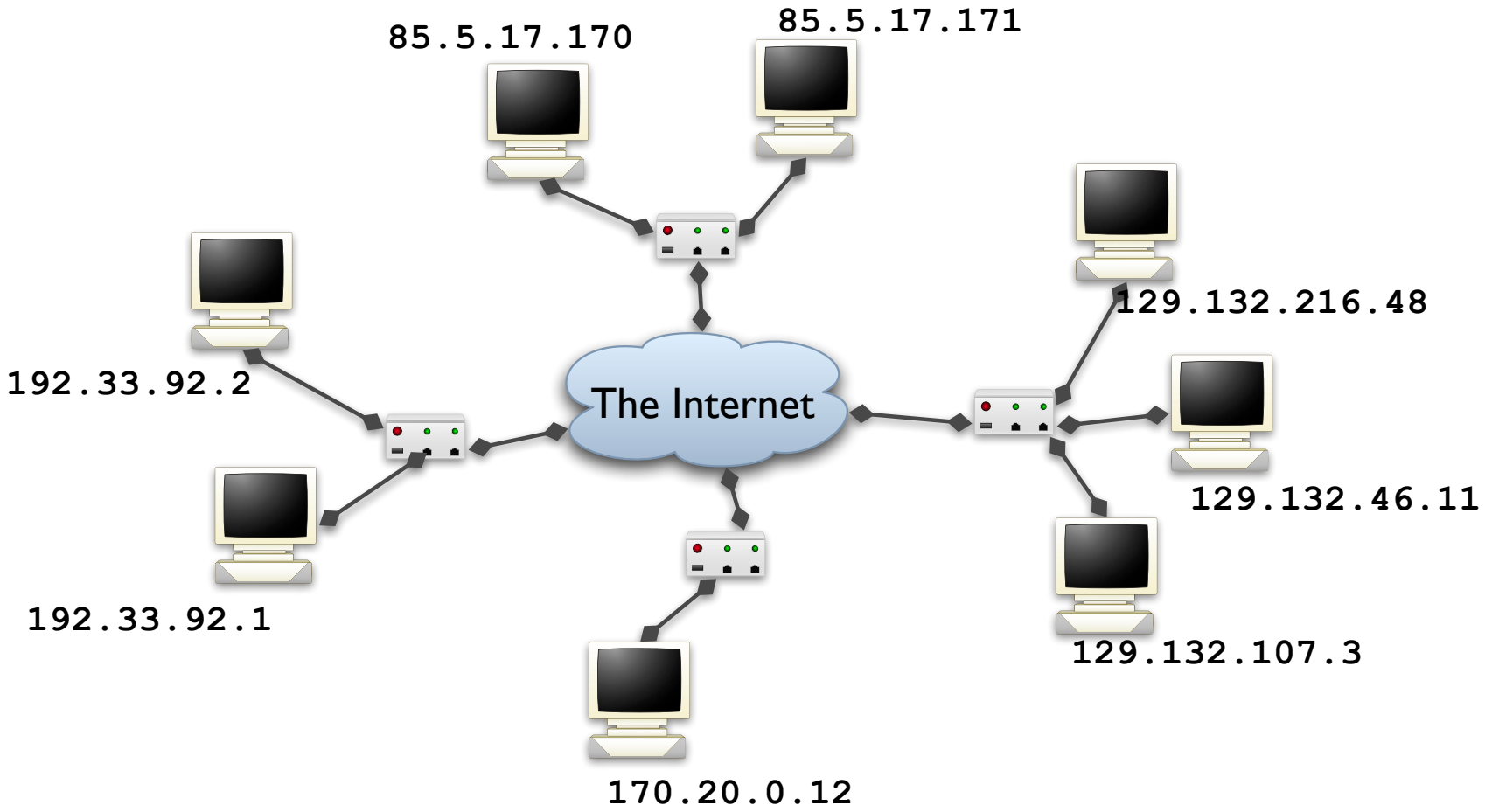
The Internet - How it was intended



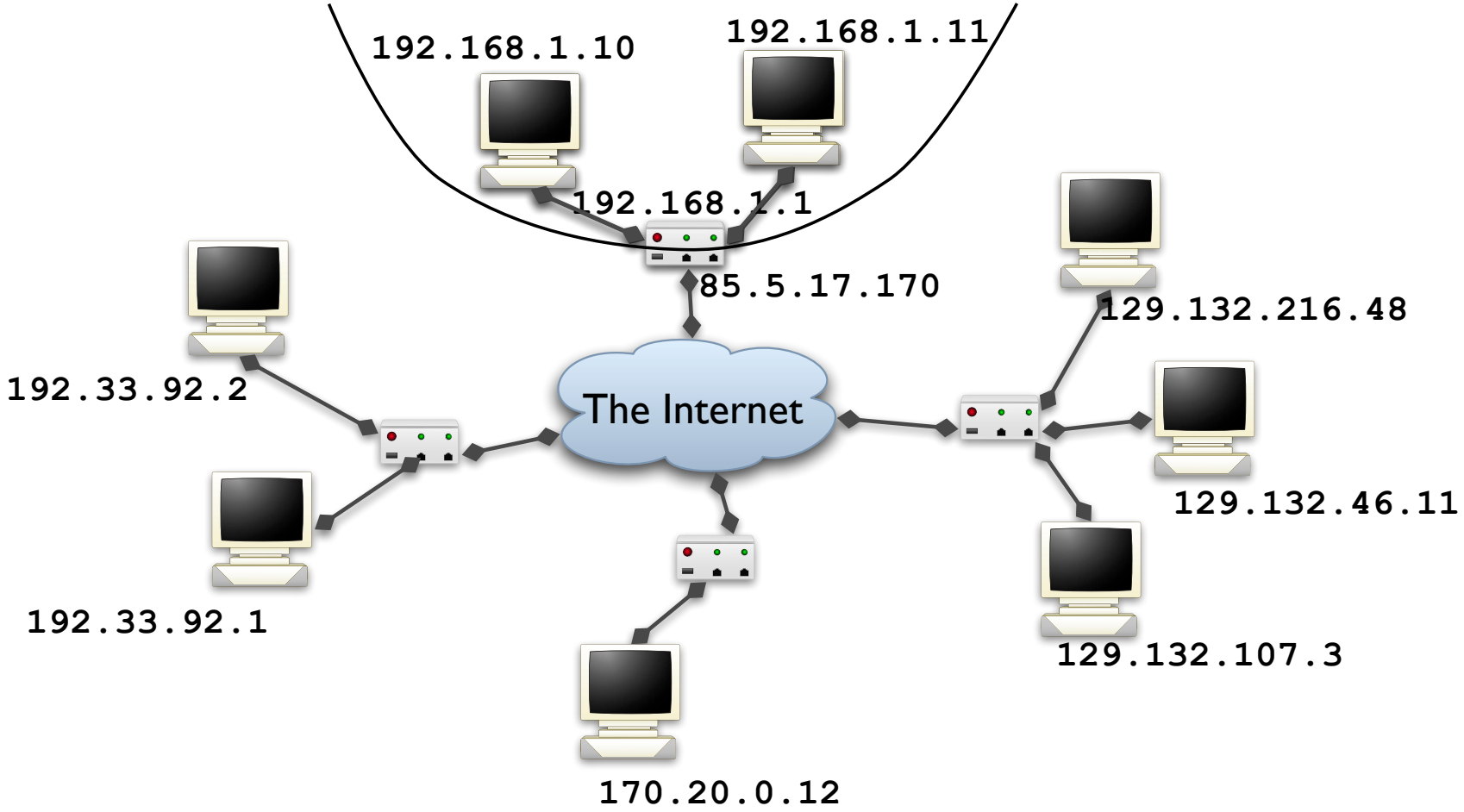
Uniform end-to-end connectivity

But what about...

- NATs
- Firewalls
- Routers
- Proxies
- …

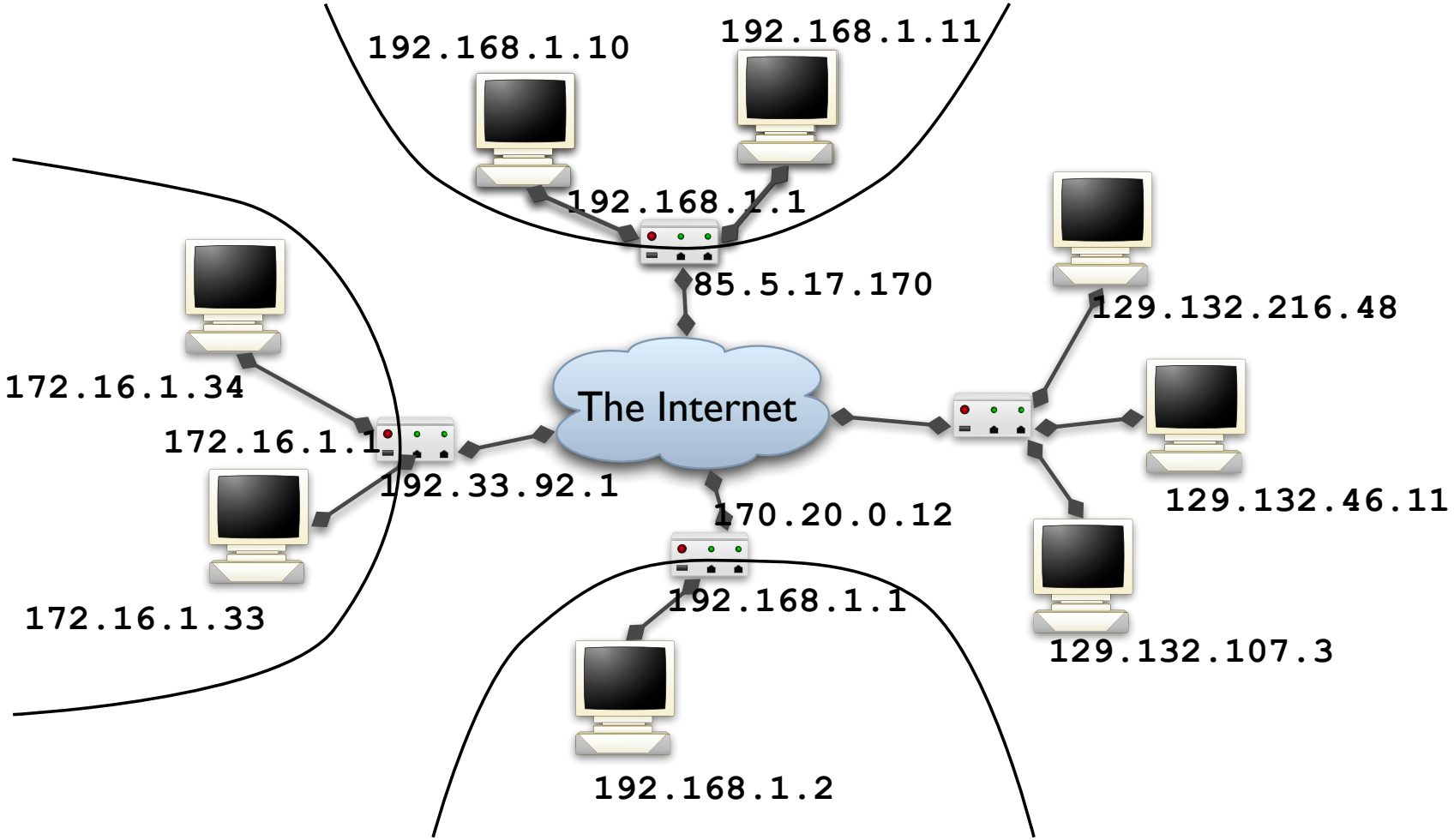
They divide the network in different regions

The Internet - How it is today



No uniform end-to-end connectivity

The Internet - How it is today

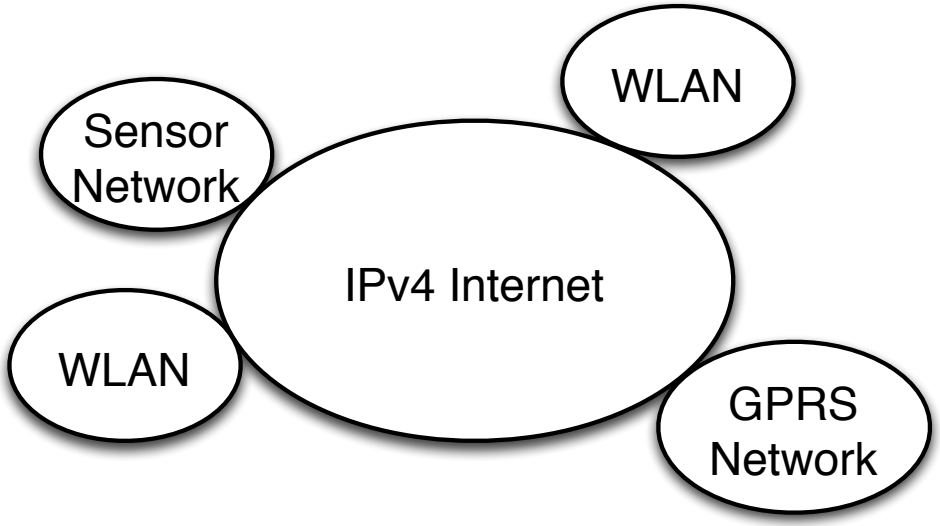


No uniform end-to-end connectivity

Introducing: Regions

Regions should be made a new architectural component.

The network is viewed as a collection of regions.



What can we do with regions?

- We assume that some invariants within a region hold.
  - Algorithms & protocols may make use of that
  - Routing might become more efficient
- The networks...
  - become more robust
  - are easier to manage
  - scale more gracefully

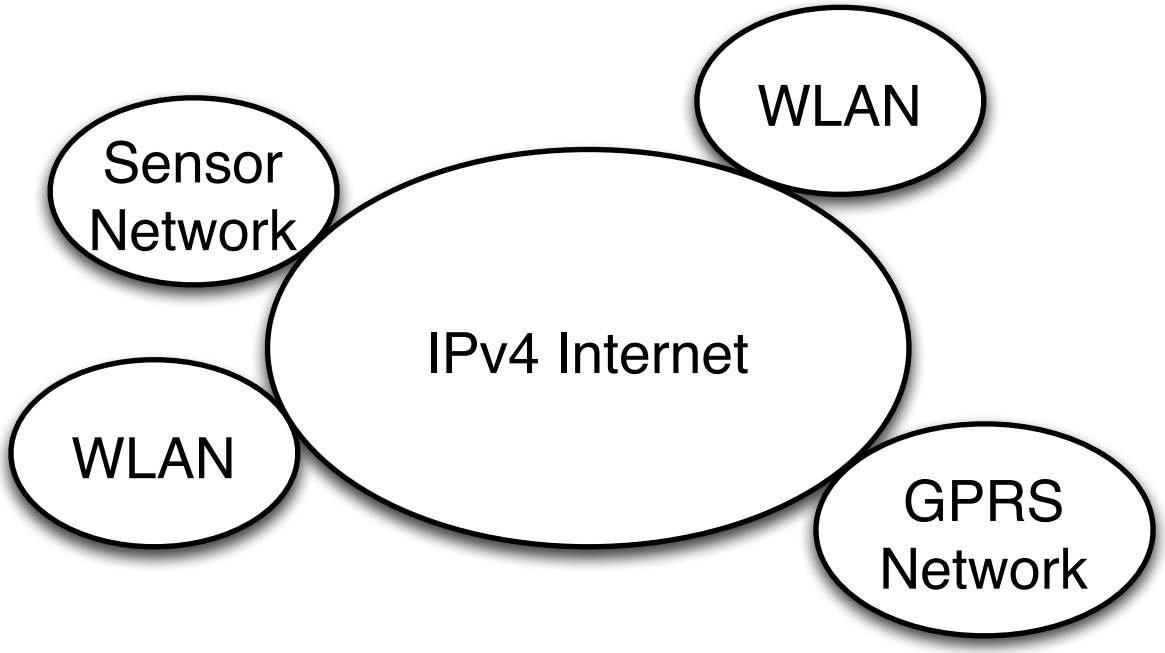
Two concepts associated with regions

- Boundary crossing
  - The goal is still end-to-end communication
  - Can the other region be trusted?
  - Inter-region-routing and addressing has to be solved
- Membership
  - All members of the regions share some common property
  - Region might be an ideal candidate to scope a search

What is „The Metanet“?

„We call a network which builds coherent user level semantics from a regionalized infrastructure and qualitatively heterogeneous communication technologies a Metanet.“ – Metanet Whitepaper

What is „The Metanet“?



- Different communication technologies
- User does not realize that

Advantages of using different technologies

- One can use special purpose infrastructure (speed, low power, ...)
- Integration of legacy infrastructure
- Simplifies the use of any available technology

The concept raises questions

- How does addressing and routing work?

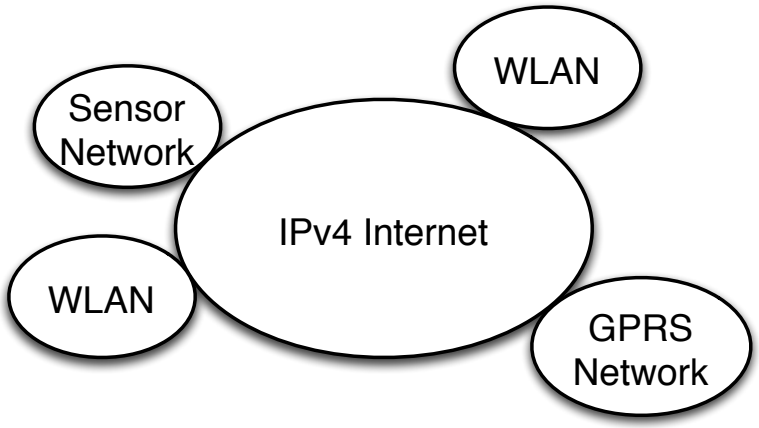
What is Plutarch?

A greek historian (46 AD - 127 AD)

A crater on the moon

What is Plutarch?

A Metanet



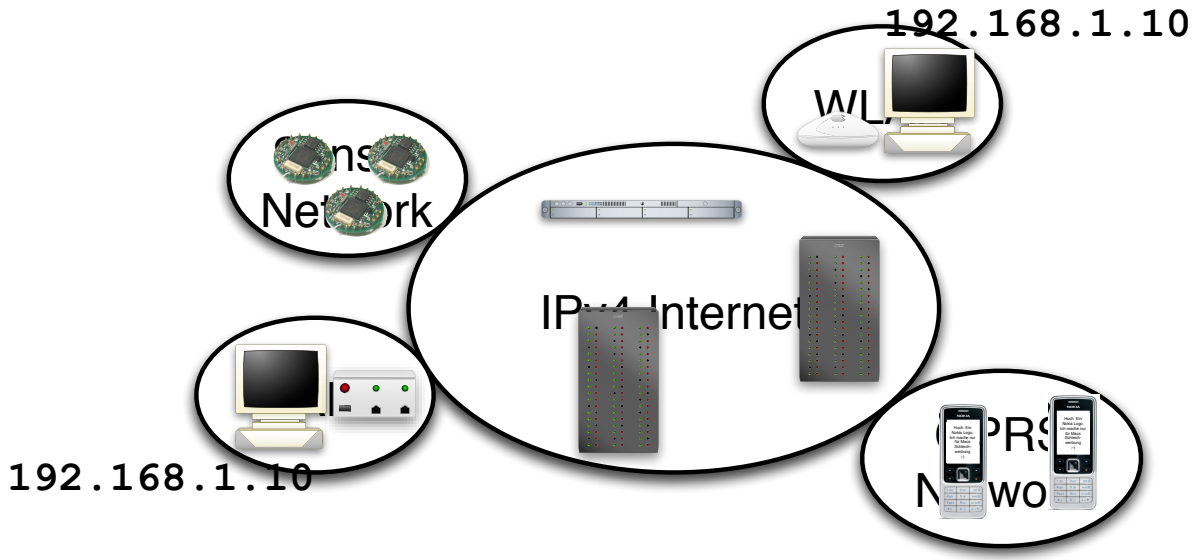
Plutarch bases on the same ideas as Metanet, but is more specific.

Motivation

- IPv4 or IPv6 may be undesirable
  - e.g. sensor networks (low power consumption)
- Original internet model is out of date
  - NATs, Firewalls, ...
- Future architectural changes
  - Plutarch provides a clearer framework

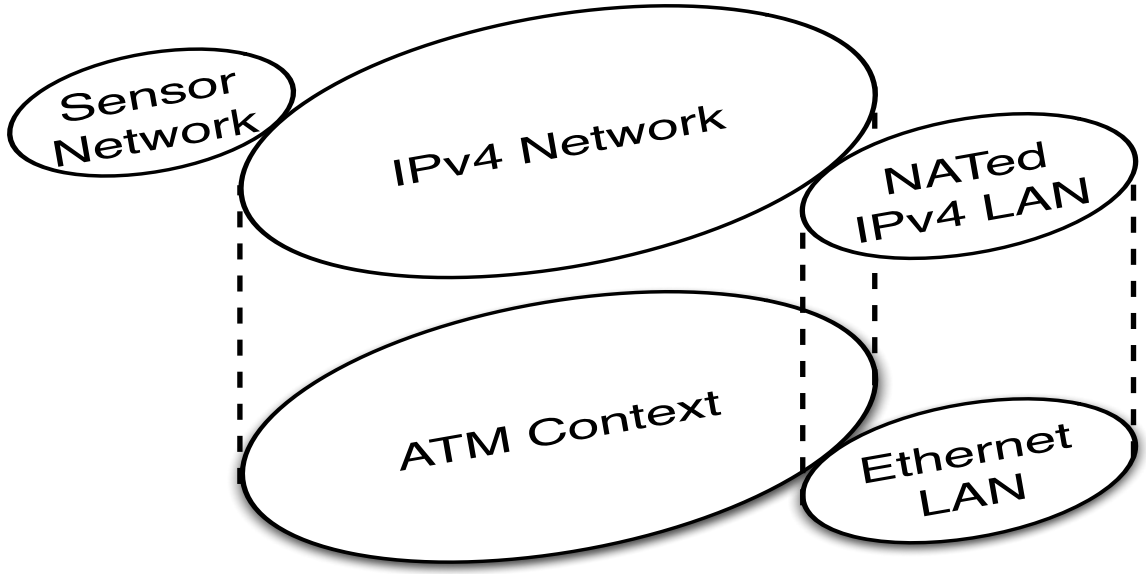
Architecture

- Network end systems exist in a context
  - The same as regions from the Metanet approach
- No global names or addresses
- Interstitial functions



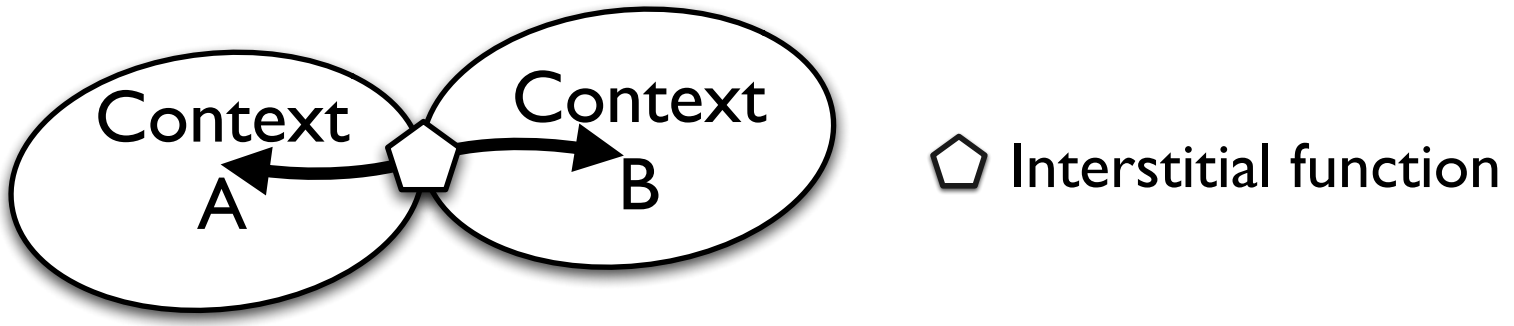
Contexts

- A context is an area in the network that is homogenous in some respect
- Protocol can be context-specific
- A machine may exist in two or more contexts
- Context membership may be dynamic

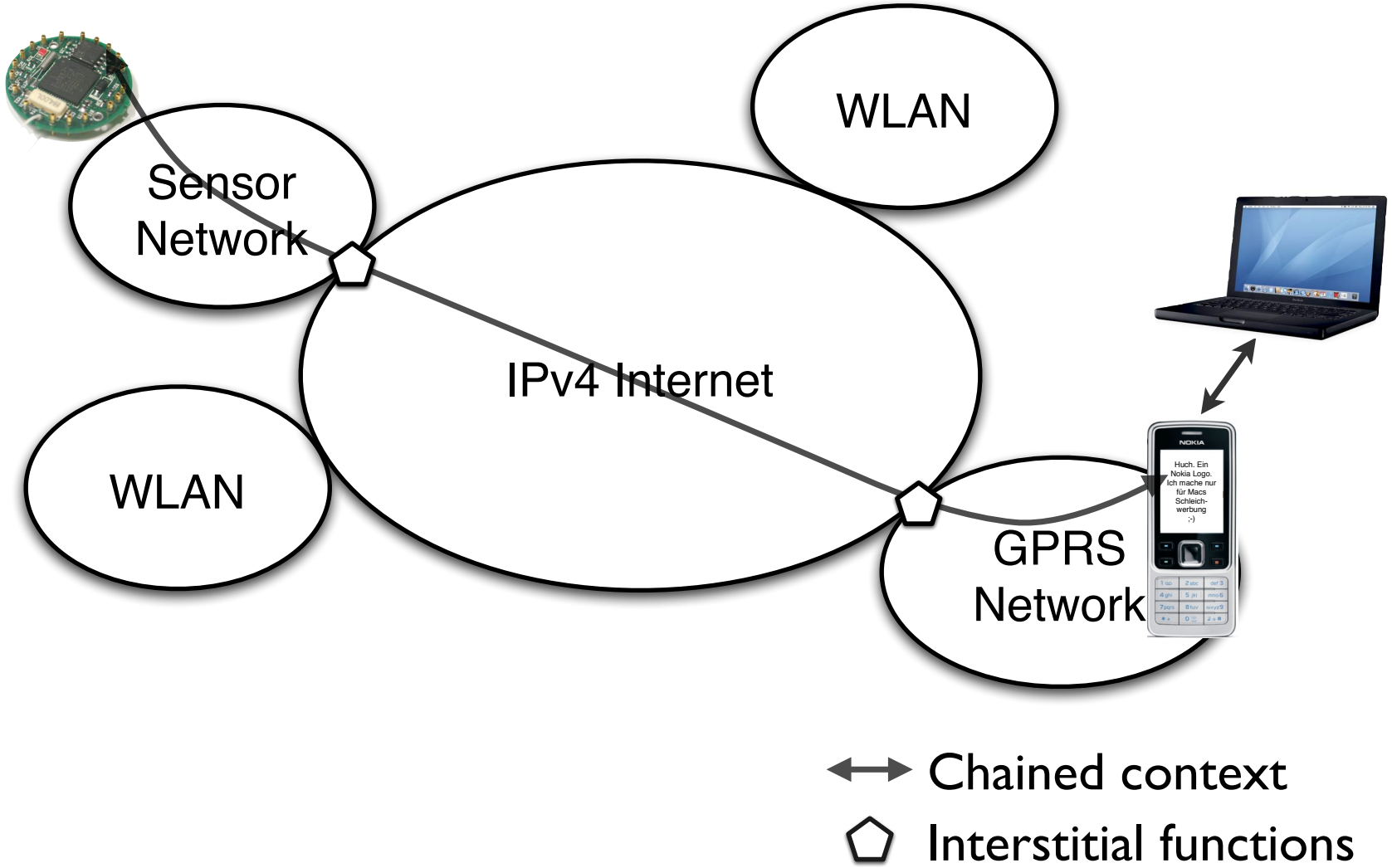


Interstitial functions (IF)

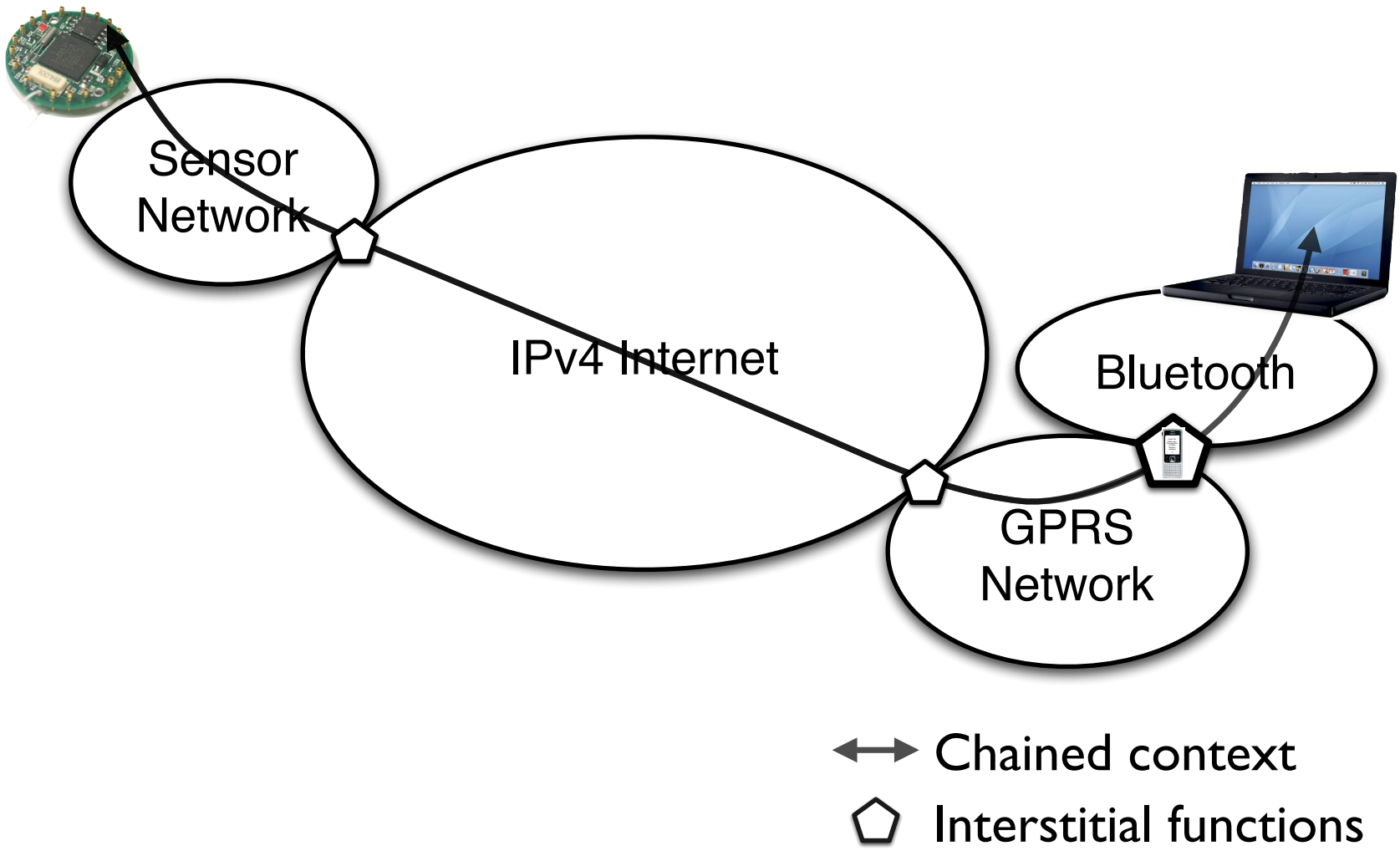
- Exist between contexts
- Transform the data to a different context
- They already exist today
  - NATs, Firewalls, ...
- Does not have to be the same protocol on both sides



Example

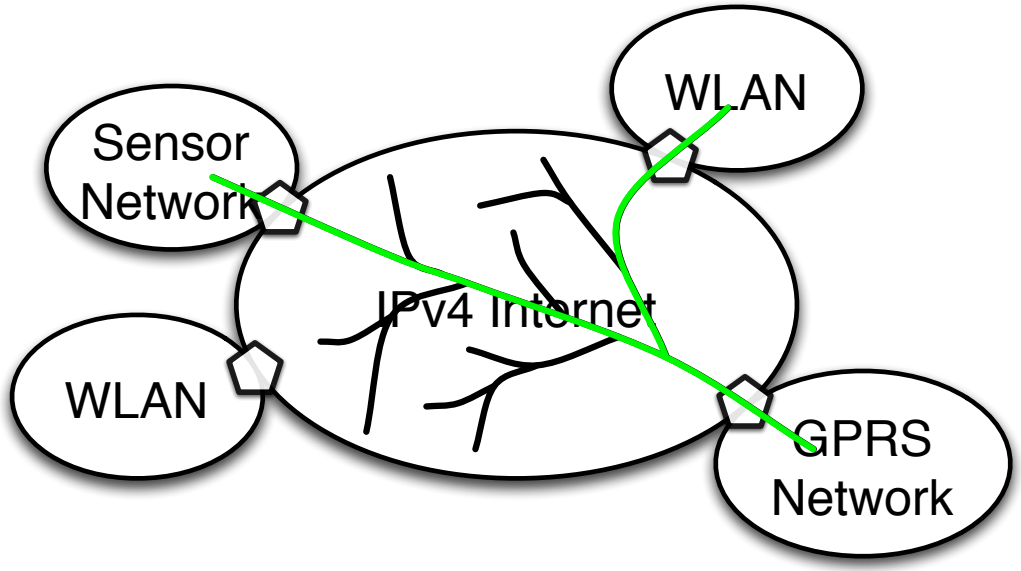

WLAN
Sensor Network
IPv4 Internet
WLAN
GPRS Network
NOKIA
Huch. Ein Nokia Logo. Ich mache nur für Macs Schleich-werbung ;-)
Chained context
Interstitial functions

Example


Sensor Network
IPv4 Internet
Bluetooth
GPRS Network
Chained context
Interstitial functions

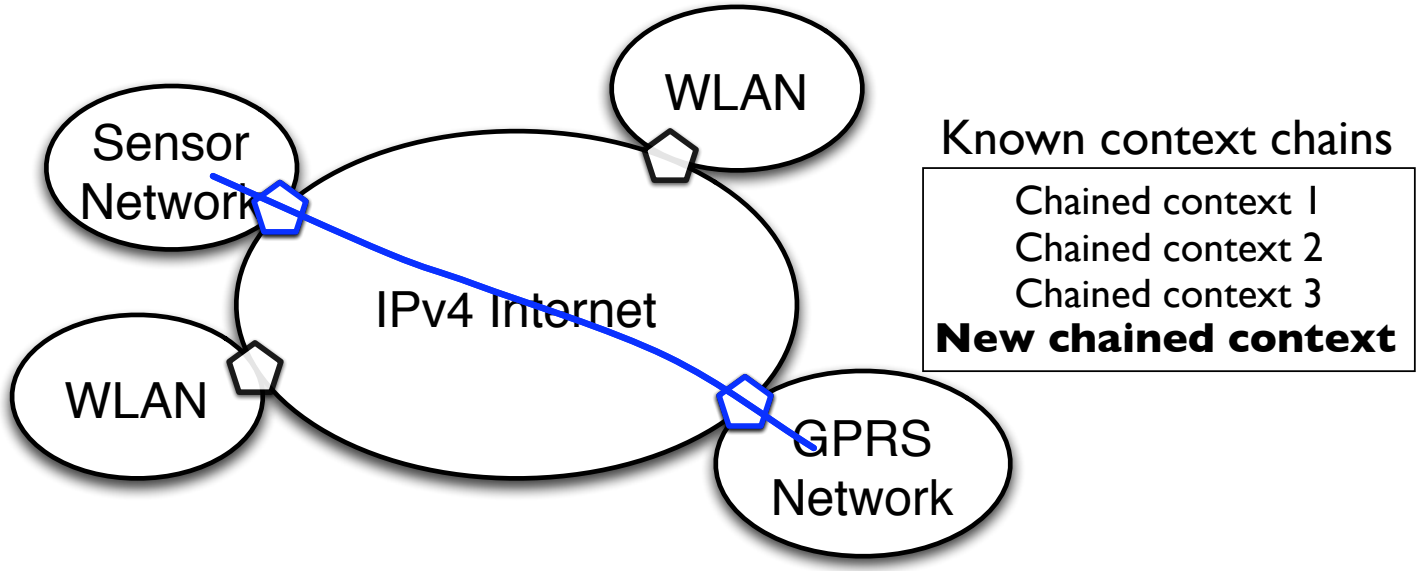
Connecting across contexts (1)

1. There is no DNS ➠ Search for the other machine
   - „epidemic-style gossip“
2. Queries result in a set of chained contexts lists
   - e.g. {(GPRS, IPv4, SN), (GPRS, IPv4, WLAN)}



Connecting across contexts (2)

3. Logic in the host selects one context chain
4. Configure Interstitial Functions
5. Instantiate the context chain and add it to the host‘s list of known contexts
6. Connection established



The concept raises questions

- How does addressing and routing work?
- How does an address look like?

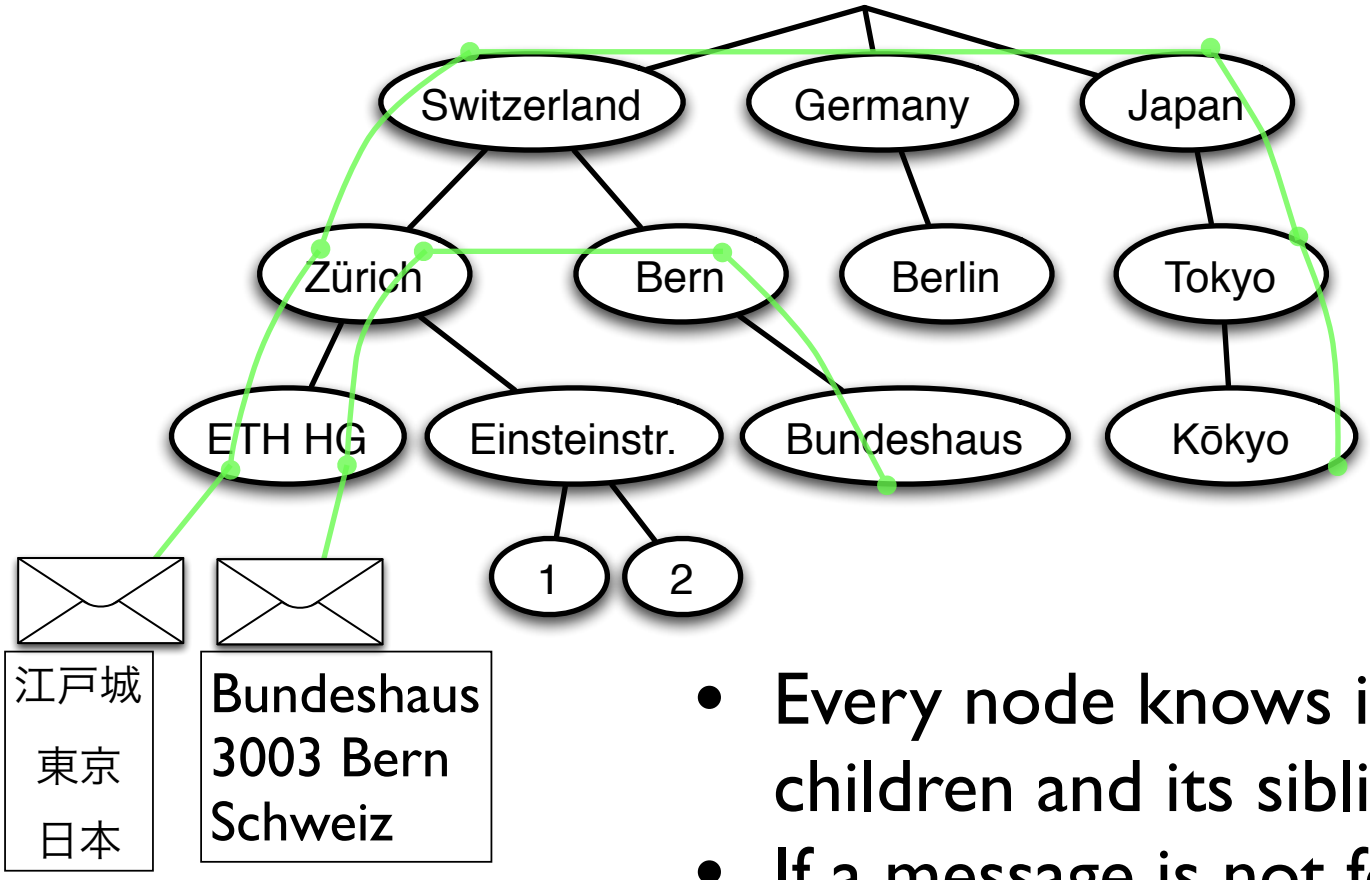
Naming & Addressing

- Naming
  - Location independent
  - e.g. URLs, personal names
- Addressing
  - Location dependent
  - e.g. postal address, IPs (?), phone numbers (?)

Example: Postal network

- The postal system has no names, only addresses
- Postal addresses are assigned hierarchically
  - Switzerland, 8092 (Zürich), Rämistrasse, 101, ...
- Default routing

Default routing



- Every node knows its children and its siblings
- If a message is not for them, pass it to the parent

Example: telephone network

- Earliest days: phone number were location specific (address)
  - Similar to postal system
- Computer-controlled telephone switches: more complex forwarding logic
  - e.g. 0800 (toll-free), 0848 in Switzerland
  - They provide an additional level of indirection
  - They are more like names masquerading as addresses

LSI & LII

- **L**ocation **S**pecific **I**dentifier
- **L**ocation **I**ndependent **I**dentifier
  - Can masquerade as LSI
- Translation from LII to LSI
  - Translation table (might result in LII ➠ recursion)
  - Default routing

Naming & Addressing

- Naming
  - Location independent
  - e.g. URLs, personal names, IPs (LII), phone numbers (LII)
- Addressing
  - Location dependent
  - e.g. postal address, IPs (LSI), phone numbers (LSI)

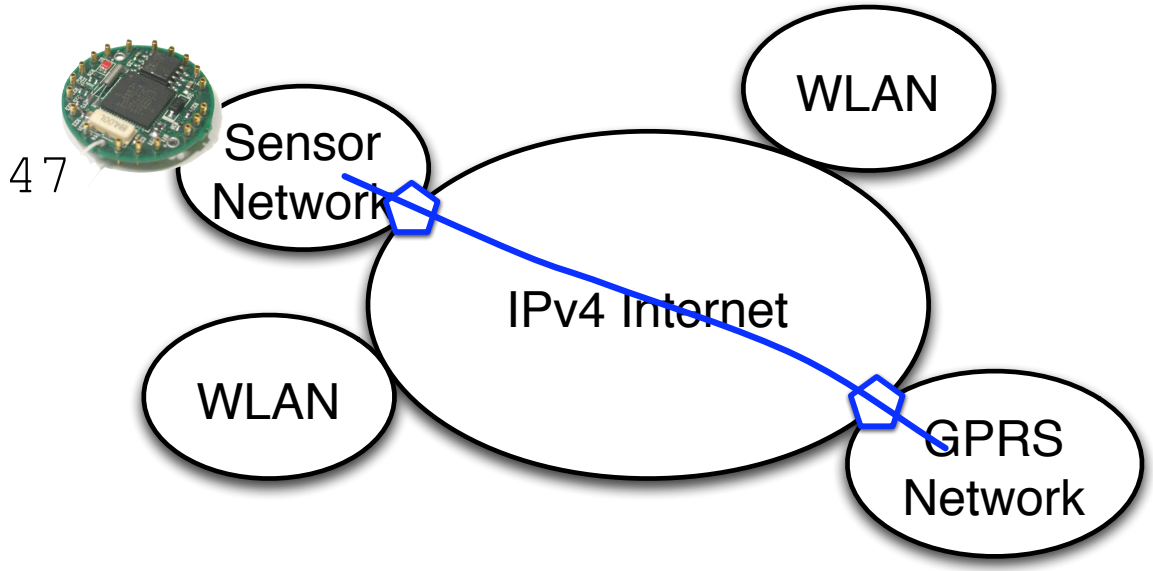
New stuff

- Naming vs. Addressing
- Default routing
- Location Specific Identifier (LSI)
- Location Independent Identifier (LII)
  - Can masquerade as LSI

Let‘s go back to Plutarch!

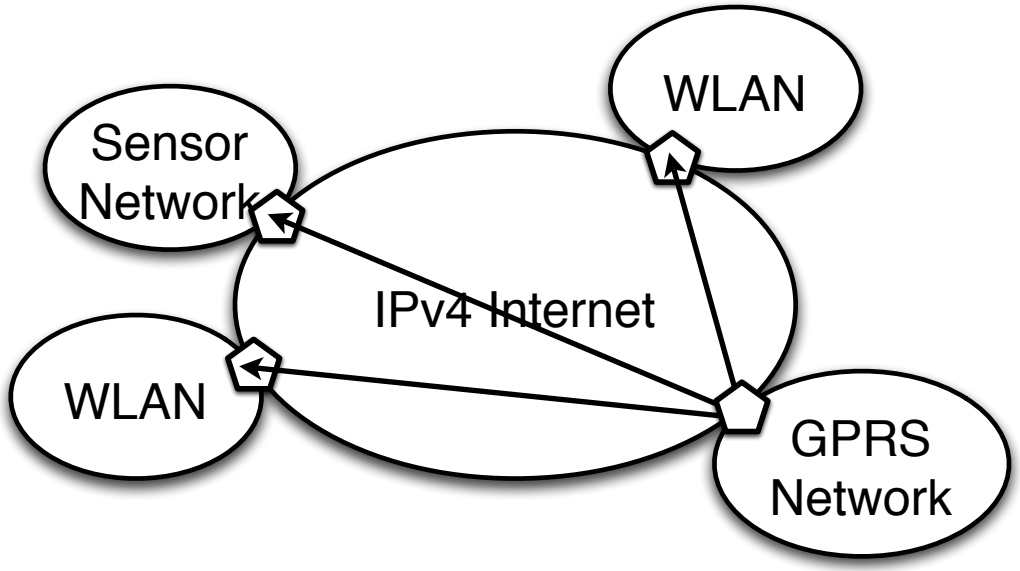
Addresses in Plutarch

- An address could be a pair of context and internal name
  - e.g. (Sensor Network, Sensor 47)
- But what about routing?



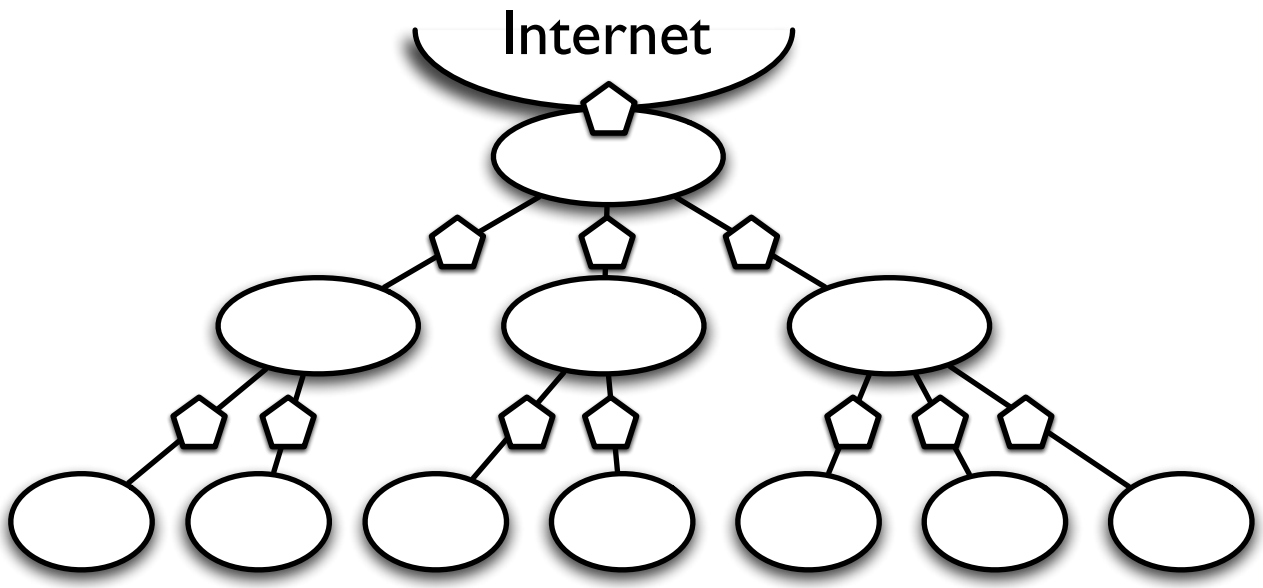
Routing in Plutarch

- IF needs to know all the other IFs
  - In the Internet that is obviously not possible
- But we can use traditional routing
  - e.g. BGP



Routing in Plutarch

- In a smaller network we might want to have a hierarchical network structure



Default routing

Plutarch: Comments on related work

- TRIAD
  - Retains the centrality of IPv4
- IPNL
  - \+ Private realm is similar to the notion of contexts
  - Retains the centrality of IPv4

Personal opinion

My personal opinion about
the Metanet and Plutarch.

- The resulting model fits the internet from today well
- It makes things easier
  - e.g. Sensor Network example
- Does not depend on IPv4 or another specific protocol

But...

Criticism (1)

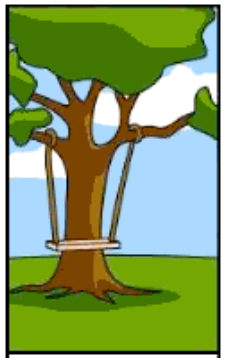
Approach

The original model of the internet is not applicable anymore.

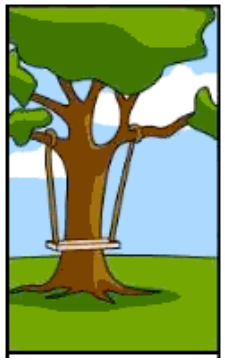
So, let's change the model!

How the software was designed

Whoops!



How the software was written



How the software was designed

Criticism (2)

Use of the old system as a starting point

Metanet and Plutarch (TRIAD & IPNL as well) try to build something new out of the old system.

Why not start from scratch? The old stuff is holding us back!

General problem in computer related areas!

Year 2038 *BIOS*

Now hiring: COBOL programmer

Clean slate (1)

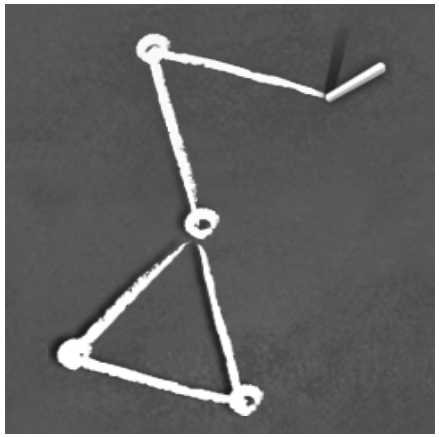
A research program at Stanford University

Two questions:

- With what we know today, if we were to start again with a clean slate, how would we design a global communications infrastructure?
- How should the Internet look in 15 years?

"The Internet? We are not interested in it."

Bill Gates, 1993

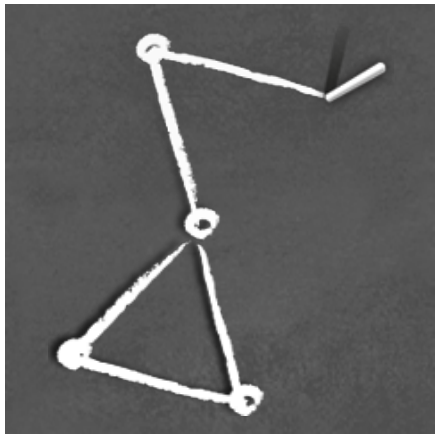


Clean slate (2)

Five key areas for research:

1. Network architecture
2. Heterogeneous applications
3. Heterogeneous physical layer technologies
4. Security
5. Economics & policy

Research in progress…



Papers

- **Plutarch: An argument for network pluralism.**

  J. Crowcroft, S. Hand, R. Mortier, T. Roscoe, A. Warfield

  http://doi.acm.org/10.1145/944759.944763

- **The Metanet: White Paper.**

  J. Wroclawski

  http://www.cra.org/Policy/NGI/papers/wroklawWP

- **Naming, Addressing, and Forwarding Reconsidered.**

  S. Keshav

  http://blizzard.cs.uwaterloo.ca/keshav/home/Papers/data/05/naming.pdf

Other Sources

- **Metanet & Plutarch (Slides)**

  B. Godfrey

  http://cs.shenker.net/files/294lecture4a.pdf

- **Plutarch: An argument for network pluralism. (Slides)**

  A. Warfield

  http://www.cs.ubc.ca/~andy/papers/plutarch-fdna.pdf

- **Clean slate**

  http://cleanslate.stanford.edu/