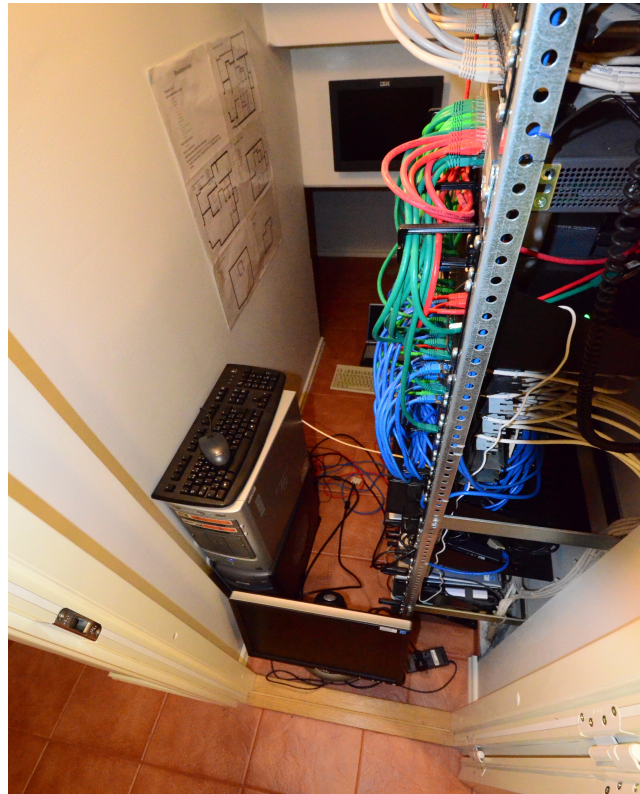# Extreme IPv6 Networking at Home

Jari Arkko

Ericsson Research

Background

This talk is about IPv6 & the Internet of Things, but

- NOT about home gateways
- NOT about ISP IPv6 service
- And NOT about new transition tools

- But it IS about IPv6 at home & elsewhere
- And about the cool things you can do with it

The Dream – No Limitations

Networking as it should be

Everything at your fingertips

- EVERYTHING is connected
- Simple end-to-end connectivity to all devices
- One web to rule them all
- No burden of legacy

EVERYTHING Is Connected

How users might see this:

- Same view, no matter where you are

  Global reachability for your devices

  For some applications, this is really important

- Devices and networks are invisible
- The same user interface for everything
- Tomorrow's Internet is not the same as today's

Proof That EVERYTHING Can Be Connected

Smart Igloos

Ari Keränen
Is the igloo melting?
En tykkääkään · Kommentoi · Näytä kaverisivu · 19 tuntia sitten lähellä paikkaa Grindelwald, Bern

👍 Sinä tykkäät tästä.

House Arkko Snow No.
19 tuntia sitten · Tykkää · 👍 2

House Arkko Snow
Whopping +25 C in the sleeping bag. Are you having a party?
Tykkää · Kommentoi · Jaa · 17 tuntia sitten via House Arkko App · 🌐

House Arkko Snow
Igloo is really warming up inside, +5 wow
Tykkää · Kommentoi · Älä seuraa julkaisua · Jaa · 4 tuntia sitten via House Arkko App · 🌐

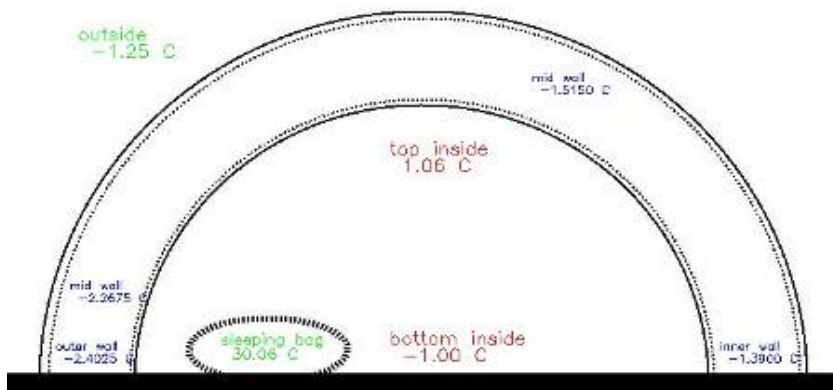**Ari Keränen** Full igloo info, please
2 tuntia sitten · Tykkää

House Arkko Snow Outside temperature is 1.19 C, inside high 3.56 C and low 3.56 C. Wall temperature in the middle and low is 0.94 C and 0.62 C higher up. Outer part of the wall is at 0.62 C, inner part is at 0.62 C. Sleeping bag is at 0.62 C.
2 tuntia sitten · Tykkää

Kirjoita kommentti…

outside −1.25 C
mid wall −1.5150 C
top inside 1.06 C
mid wall −2.3675 C
outer wall −2.4025 C
sleeping bag 30.06 C
bottom inside −1.00 C
inner wall −1.3900 C

Smart Energy

Smart energy is about energy conservation with better appliances, more information, and coordination

Countless organisations work on this around the world

And They Got It All Wrong THIS Is Smart Energy

Thermostat →

CPU/GPU (inside)

Network

Power

Heater that pays your electricity bill?

Heating device - a resistor that converts electricity into heat

Computing device – does some useful work *and* converts electricity into heat
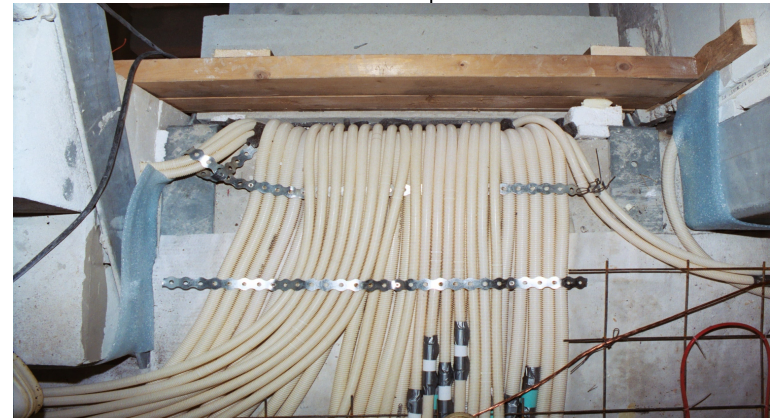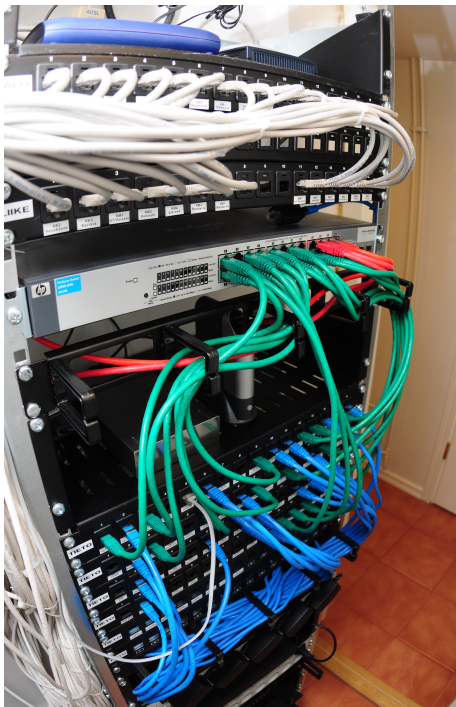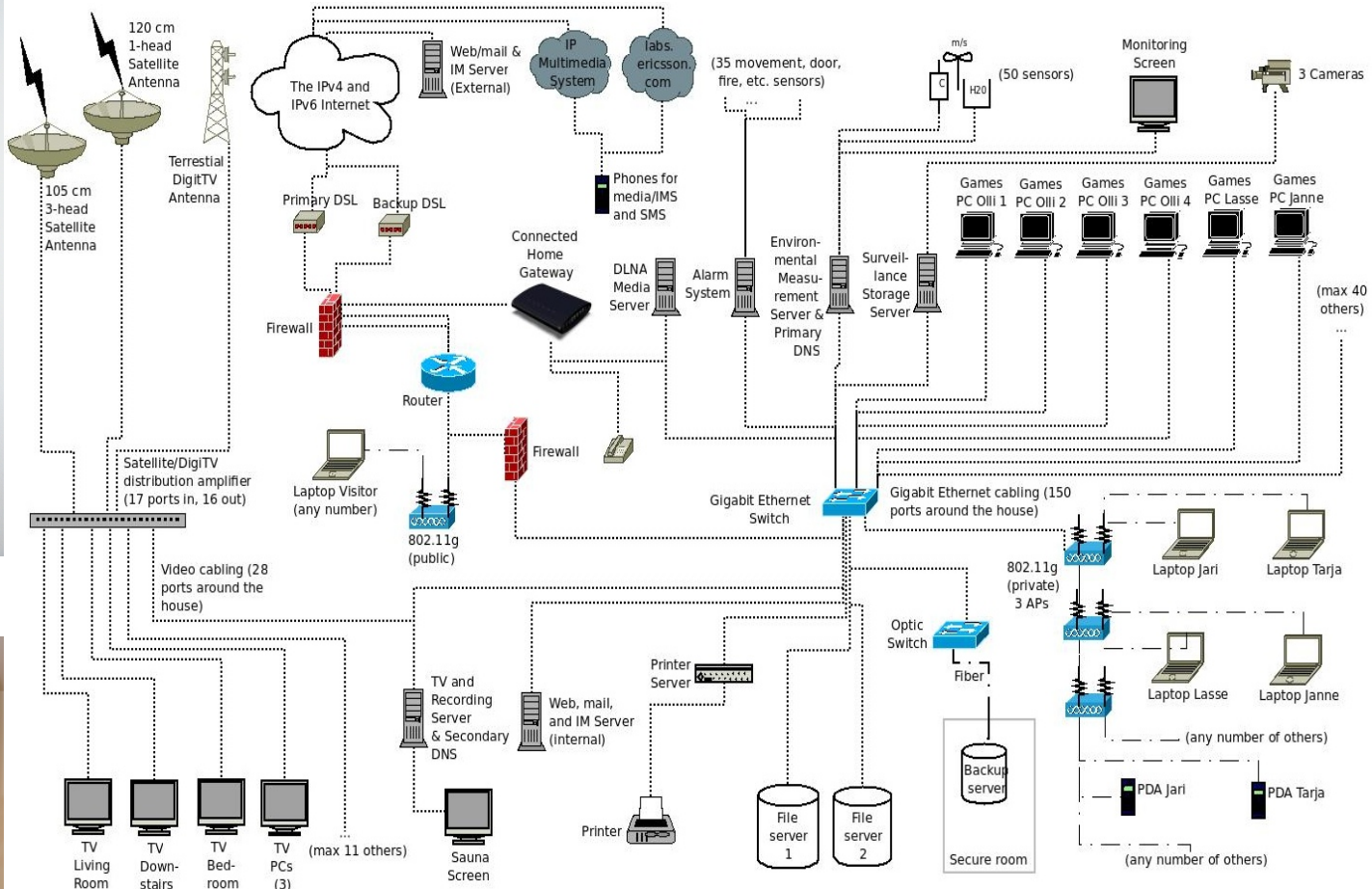
Bitcoin mining, etc

Simple End-to-End Connectivity

The dream: it just all works

No matter how many boxes you have

And how you connect them

- Networks shall have address space
- Routers shall know where to send packets
- Names resolve to addresses
- Human touch is NOT required

120 cm
1-head
Satellite
Antenna

105 cm
3-head
Satellite
Antenna

Terrestial
DigiTV
Antenna

The IPv4 and
IPv6 Internet

Web/mail & IM Server
(External)

IP Multimedia System

labs.
ericsson.
com

(35 movement, door,
fire, etc. sensors)

m/s

C   H2O

(50 sensors)

Monitoring
Screen

3 Cameras

Games
PC Olli 1

Games
PC Olli 2

Games
PC Olli 3

Games
PC Olli 4

Games
PC Lasse

Games
PC Janne

Primary DSL

Backup DSL

Phones for
media/IMS
and SMS

Connected
Home
Gateway

DLNA
Media
Server

Alarm
System

Environ-
mental
Measu-
rement
Server &
Primary
DNS

Surveil-
lance
Storage
Server

(max 40
others)

Firewall

Router

Firewall

Satellite/DigiTV
distribution amplifier
(17 ports in, 16 out)

Laptop Visitor
(any number)

802.11g
(public)

Gigabit Ethernet
Switch

Gigabit Ethernet cabling (150
ports around the house)

802.11g
(private)
3 APs

Laptop Jari

Laptop Tarja

Laptop Lasse

Laptop Janne

Video cabling (28
ports around the
house)

Optic
Switch

Fiber

(any number of others)

TV and
Recording
Server
& Secondary
DNS

Web, mail,
and IM Server
(Internal)

Printer
Server

Backup
server

PDA Jari

PDA Tarja

TV
Living
Room

TV
Down-
stairs

TV
Bed-
room

TV
PCs
(3)

(max 11 others)

Sauna
Screen

Printer

File
server
1

File
server
2

Secure room

(any number of others)

Ericsson Internal

Zero-Configuring Homes
IETF HOMENET WG

- Use existing tools (DHCP PD, RAs, OSPF)
- "Route where you had NAT44" architecture
- Add small enhancements where needed to ensure automatic self-configuration
  - Automatically turning routing on
  - Prefix discovery and assignment
  - DNS discovery and MDNS across the home

A HOMENET Network
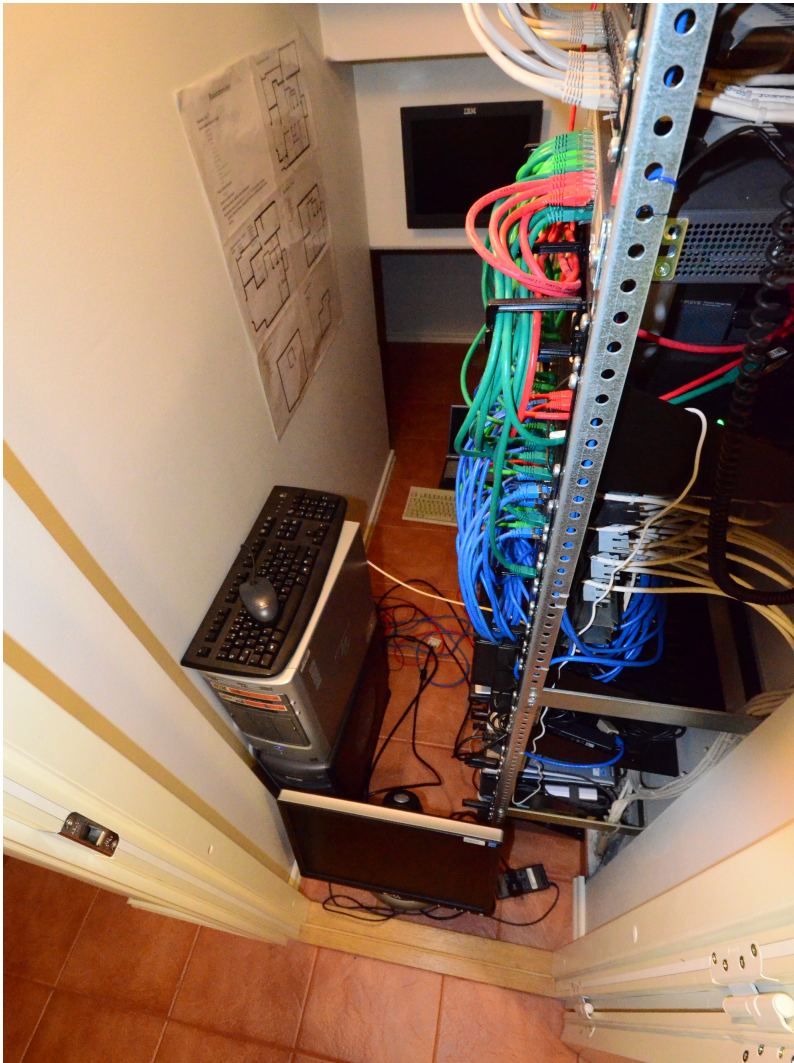
Router ID

Prefix

```
hord: debug: 21897, OSPF: Timeout causes a message resend
hord: debug: 21897, RAW: sendto destination fe80::20c:46ff:fe16:9c86
^C
root@newrouter:/tmp# cat /etc/hord/events
Selected own router ID: 16.191.119.86
Selected own hardware fingerprint: 16.191.119.86
Automatically assigned a prefix to an interface on interface eth1: 2001:db8:beef:ddd6::/64
Added a new neighbor on interface eth1: 49.66.233.220
Received a valid DD message from neighbor with sequence number on interface eth1: 49.66.233.220 1954
Neighbor moves to EXSTART state on interface eth1: 49.66.233.220
DD sequence number to a neighbor initialized on interface eth1: 1008170920
Tentatively selecting ourselves as the master for the neighbor on interface eth1: 49.66.233.220
New DD message sent with sequence number, in response to a sequence number on interface eth1: 100817
This router becomes a slave to the following peer on interface eth1: 49.66.233.220
Negotiation done, moving to state EXCHANGE with neighbor on interface eth1: 49.66.233.220
```

```
root@nat64: /tmp
Tiedosto  Muokkaa  Näytä  Etsi  Pääte  Ohje
root@nat64:/tmp# host -t aaaa www.slashdot.org 2001:14b8:400:f3c:21a:9fff:fe0b:811
Using domain server:
Name: 2001:14b8:400:f3c:21a:9fff:fe0b:811
Address: 2001:14b8:400:f3c:21a:9fff:fe0b:811#53
Aliases:

www.slashdot.org has IPv6 address 2001:14b8:400:f3f::d822:b530
root@nat64:/tmp# cat /etc/nat64.conf
pref64 = 2001:14b8:400:f3f::/64
out_pref46 = 10.70.0.0/24 ;
ports = 40000-60000 ;

interface = ext:eth0:drop_enabled ;
    filter_prefixes = 10.70.0.0/24 ;
interface = int:nat64:drop_enabled ;
    filter_prefixes = 2001:14b8:400:f3f::/64 ;
root@nat64:/tmp# cat /etc/radvd.conf

interface eth3
{
  AdvSendAdvert on;
  MaxRtrAdvInterval 3;
  MinRtrAdvInterval 1;
  AdvIntervalOpt on;
  prefix 2001:14b8:400:f3c::/64
  {
  };
  RDNSS 2001:14b8:400:f3c:21a:9fff:fe0b:811
};
root@nat64:/tmp# 
```
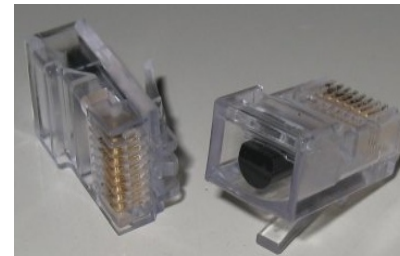
NAT64 config

RA & PIO

DNS discovery

Some Early Experiences

- First implementation one year ago

- Now there are multiple implementations, open source, interop tests, IETF demos, …

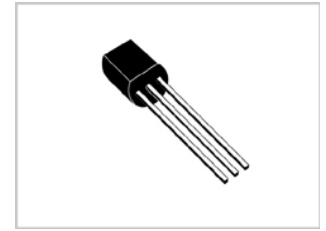- Future? A bright future would be to have this become part of usual home router software
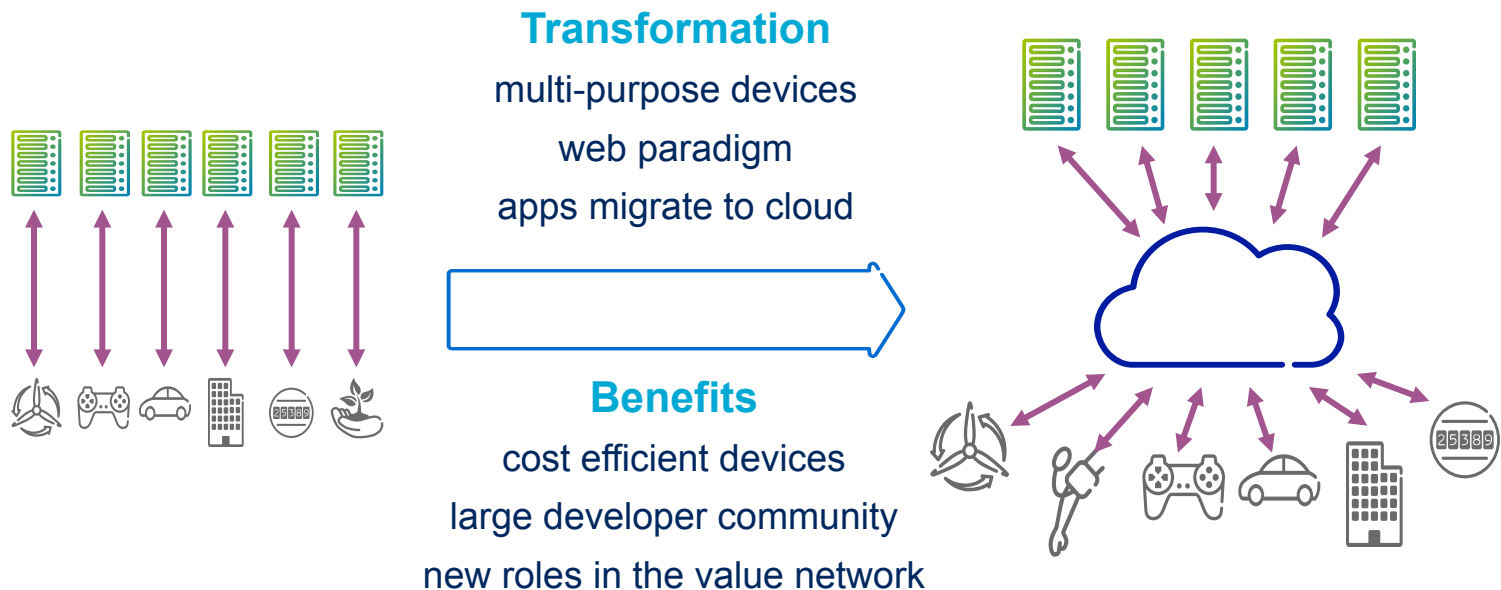
One Web to Rule Them All

Experiences from Implementing and Using the Internet of Things

Some Experiences

- Legacy devices are moving to an all-IP model
- It is important to reach interoperability at all layers; formats and web interfaces are very important too, not just IP
- The key is general purpose technology (3G, WLAN, web)
- Web tools is the way the market is going

Transformation

multi-purpose devices

web paradigm

apps migrate to cloud

Benefits

cost efficient devices

large developer community
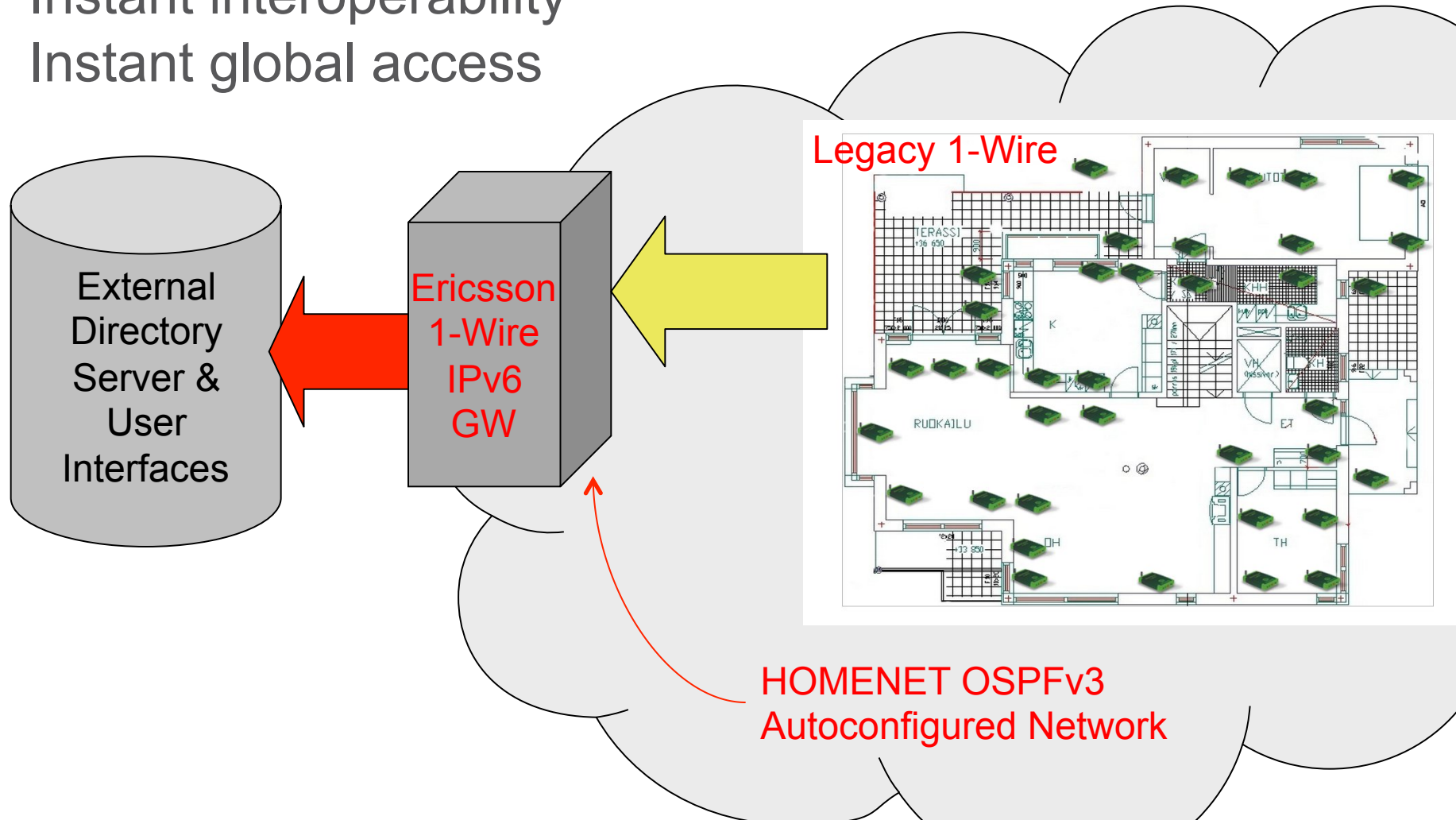
new roles in the value network

No Burden of Legacy

Integrating and Ignoring Legacy

Power of web tools, IPv6, and CoAP:
Make it look like a resource
Instant interoperability
Instant global access

External Directory Server & User Interfaces

Ericsson 1-Wire IPv6 GW

Legacy 1-Wire

HOMENET OSPFv3 Autoconfigured Network

Case IPv4 Legacy

Without IPv4 for 3 years

I was able to do all my work and entertainment

We did this for testing an early NAT64 device, eating our own dogfood, and to prepare the way for others

Considerable progress in 3 years; but still some pain points today

Summary

- You can connect everything
- The network can configure itself completely
- If there is legacy, don't keep it around – isolate it somewhere, and build your new network right
    - Do not build everything to the IPv4 blueprint
- Make everything speak the web and you can build wonderful things easily