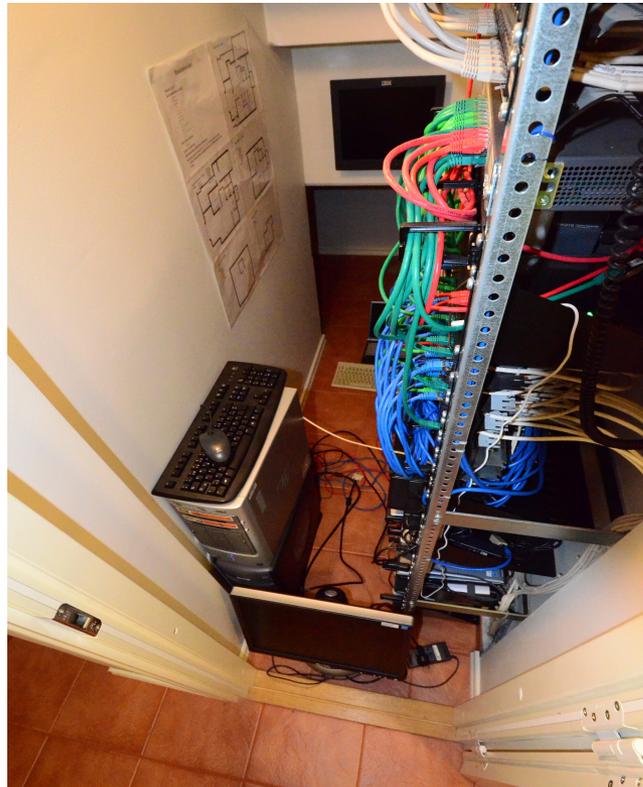


Extreme IPv6 Networking at Home



Jari Arkko, Ericsson

With thanks to Acee Lindem, Ari Keränen, Jan Melen, Fredrik Garneij, Mark Townsley, Lorenzo Colitti, Zach Shelby, Matthew Vial, Martti Kuparinen, Tero Kauppinen, Heidi-Maria Rissanen, Cullen Jennings, Jan Höller, Olli and Lasse Arkko, and many others



Work partially funded by the Tekes IOT SHOK project.

Background



This talk is about IPv6, but

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

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

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

How a User Might See This

All the familiar tools

Same view, no matter where you are

Devices and networks are invisible

The image shows a screenshot of a Facebook page for 'House Arkko Laundry' and a chat window. The Facebook page includes a search bar, a profile picture, and a post that says 'Laundry is dry'. The chat window shows a message from 'Talo Arkko' at 10:44:56 PM: 'Door open in Entrance'. Below the chat window is a diagram of a house with a central box labeled 'IV' and four arrows indicating energy flow: two blue arrows pointing left (-13.31 C and -2.38 C) and two red arrows pointing right (18.75 C and 23.94 C). The text 'kitchen.objez.net' is written diagonally across the diagram.

Proof That EVERYTHING Can Be Connected



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

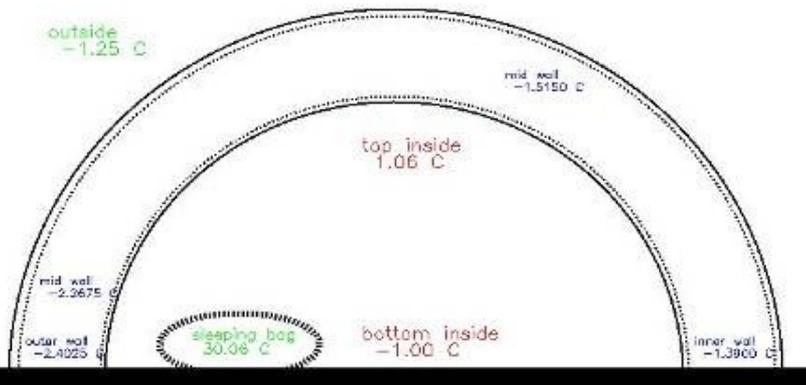


House Arkko Snow Outside temperature is 1.19 C, inside high 3.56 C and low 3.56 C. Wall temperature in the middle and low is 0.94 C and 0.62 C higher up. Outer part of the wall is at 0.62 C, inner part is at 0.62 C. Sleeping bag is at 0.62 C.

2 tuntia sitten · Tykkää



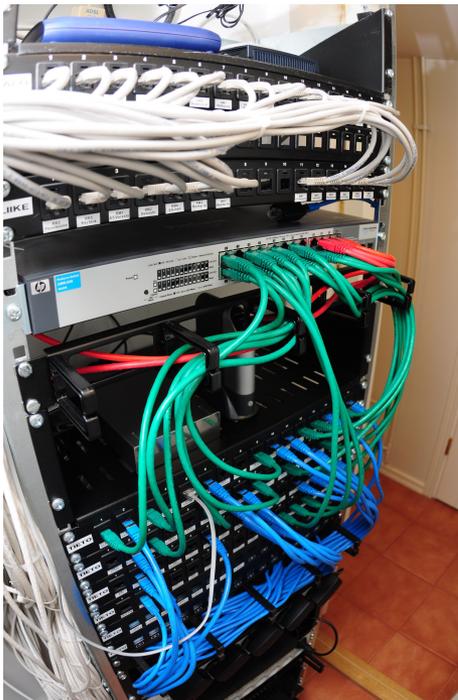
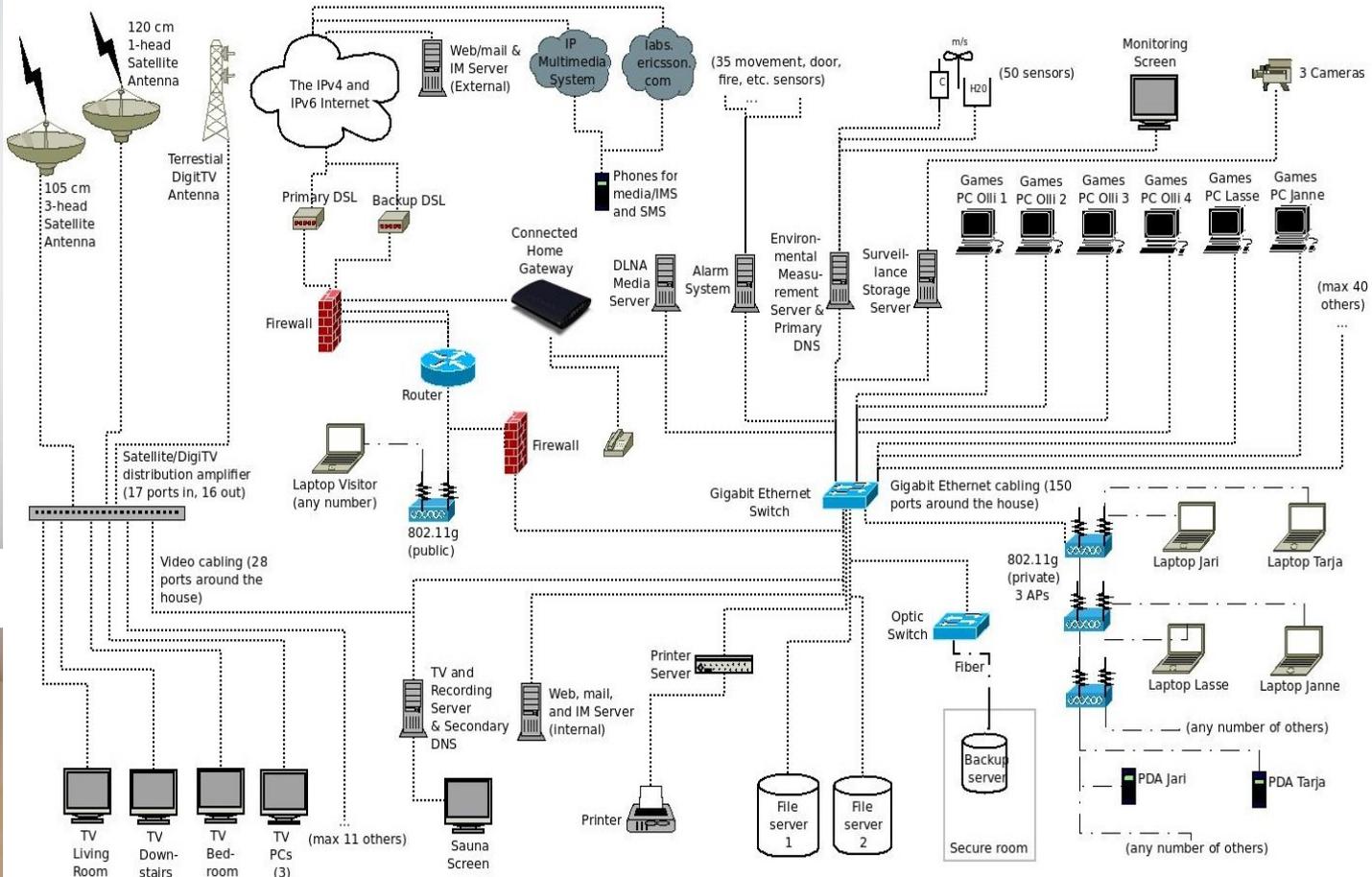
Kirjoita kommentti...



The Dream – It Just 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
[Especially by my mother!]



Zero-Configuration

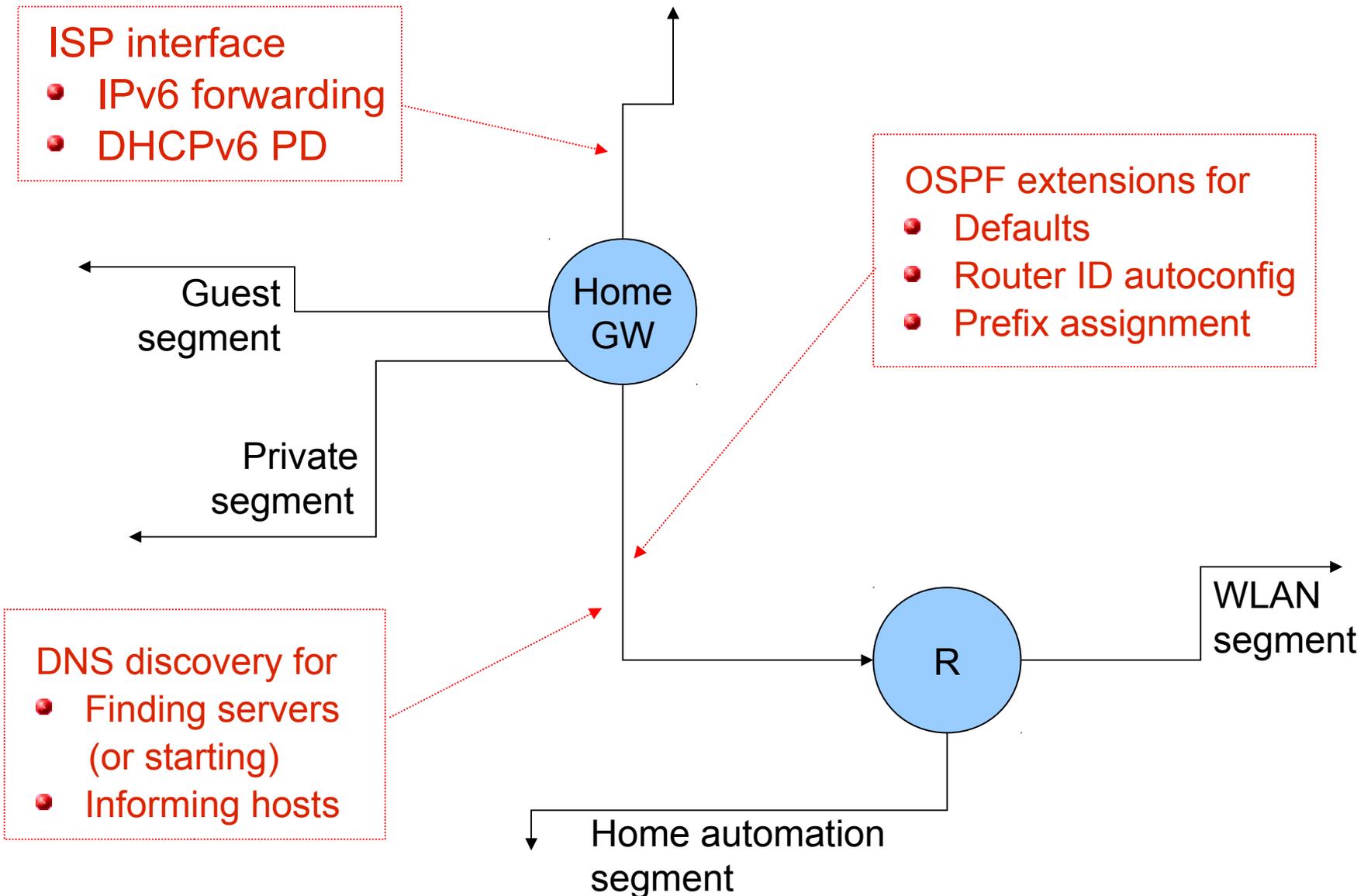
Implementing and Using HOMENET



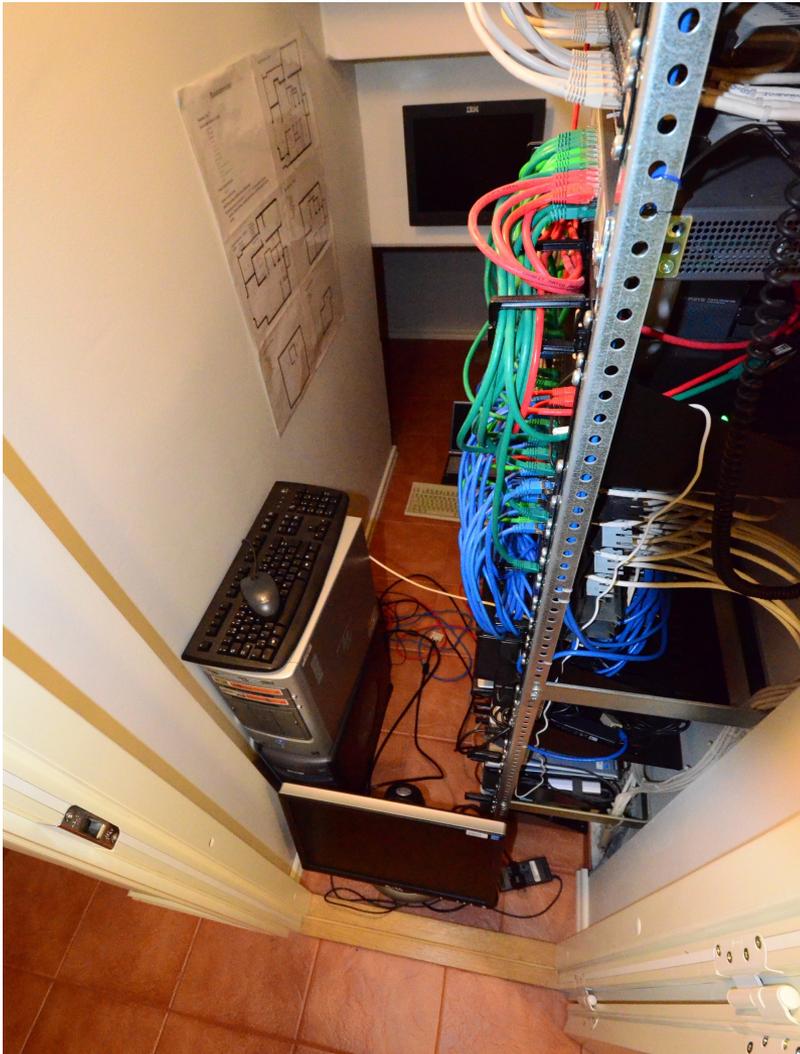
Zero-Configuring Homes per IETF HOMENET WG

- 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

OSPFv3-Based Home Networking



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: 49.66.233.220 195
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# 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 from Zero-Configuration

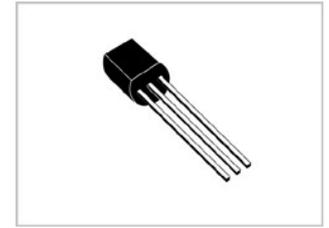
- The technology seems to work as intended
- Also enables many new things
- Our understanding of the problems developed as the work continued
- Relatively easy to implement
(If you are not crazy enough to implement OSPFv3 from scratch)
- Interfaces to other systems

Connecting Everything

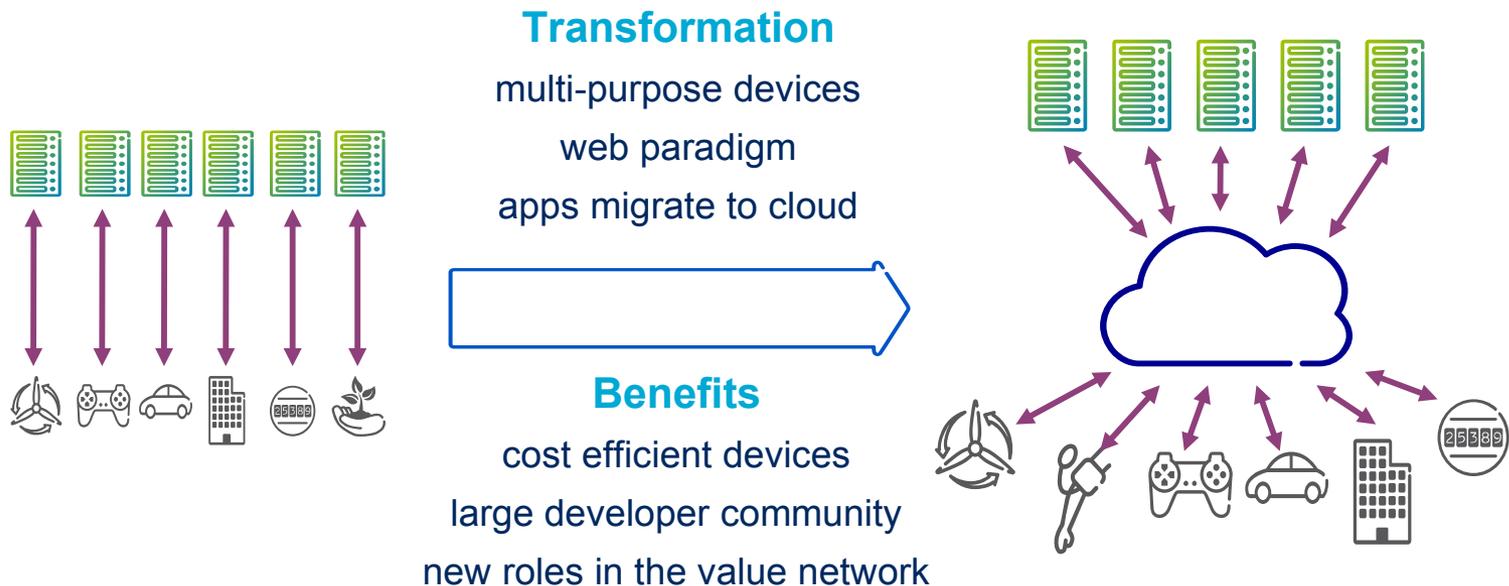
Implementing and Using the Internet of Things



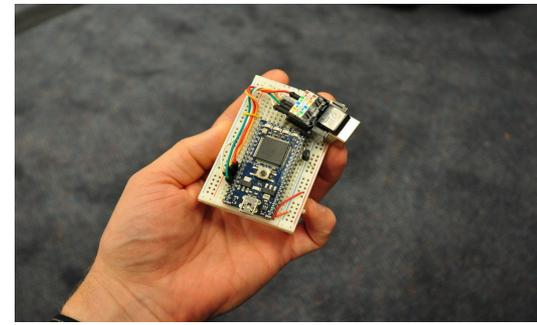
Some Experiences



- 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 Right Way to Deploy the Internet of Things



- The key is general-purpose technology
- We need more general-purpose link-layers, more web technology, more standard switches, routers, and servers
- My cat6 network has been tremendously flexible resource
- Now we will see the same with my Ethernet & IPv6 networks and various web tools in the cloud

Recommended Technologies



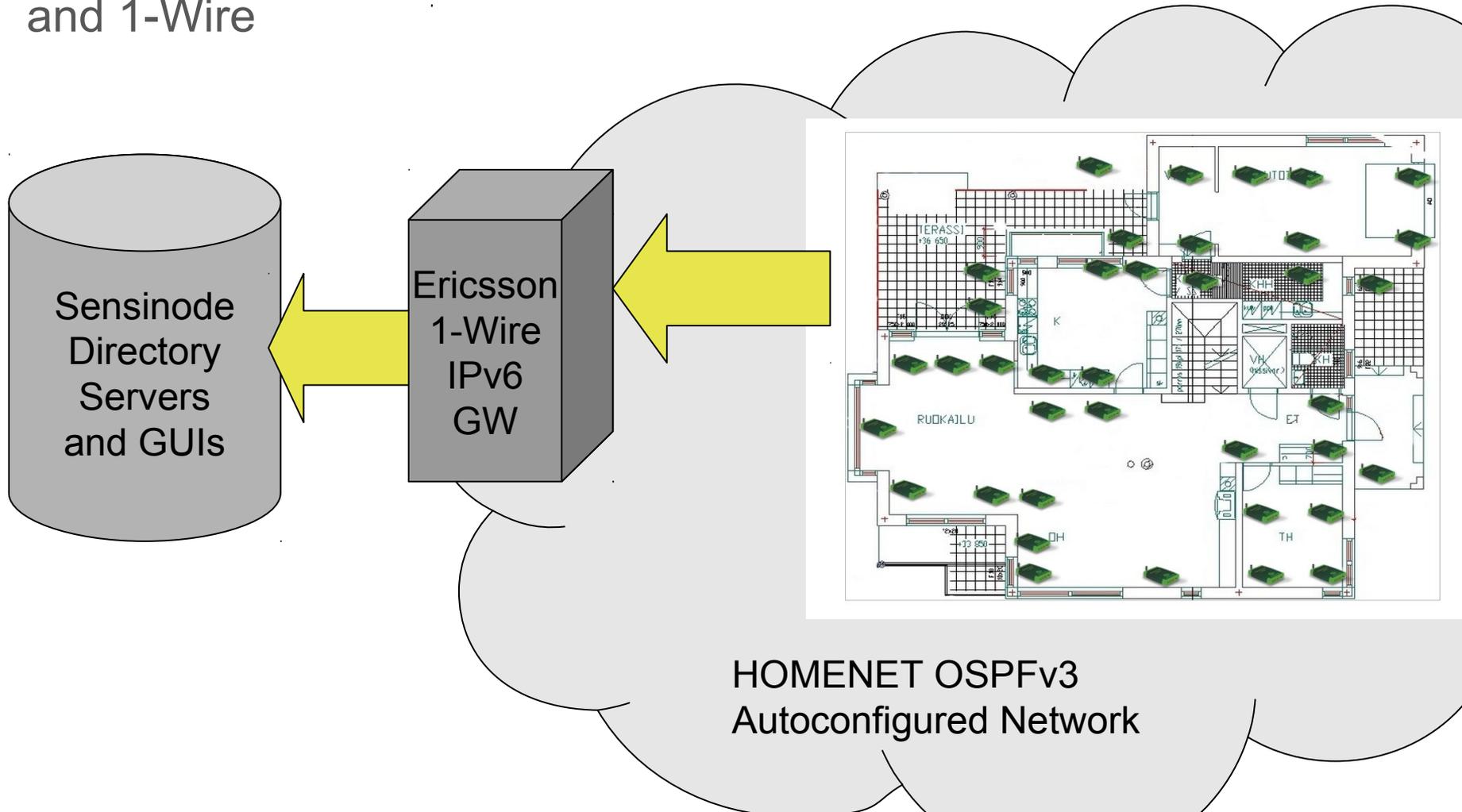
- WLAN, 2G/3G/4G, Ethernet, BT – easy to deploy, widely supported, coverage
- REST over HTTP or COAP – universal connectivity with REST-based interfaces
- JSON, SenML, XML – easily processed formats
- General-purpose tiny computers and OSes; CPUs instead of logic



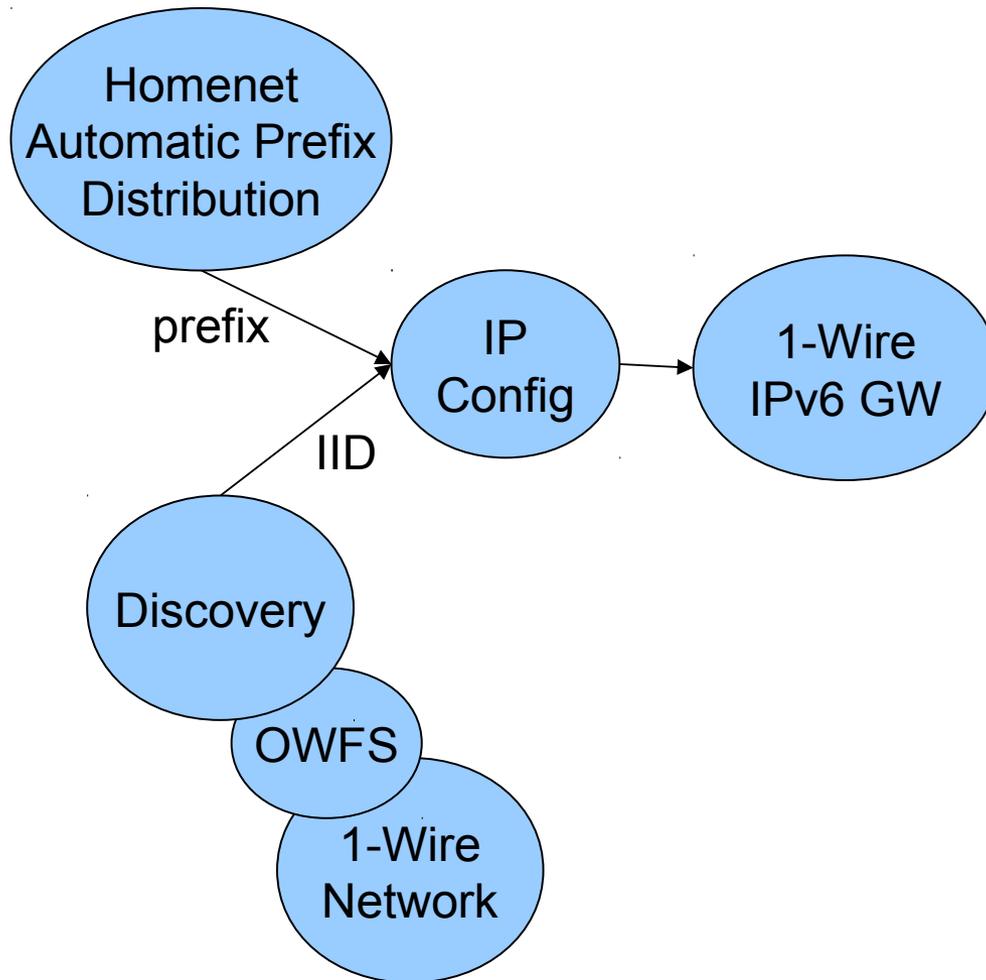
The Power of Web Tools – Example

Connecting my sensors to tools in the Internet,
with IPv6 and CoAP

Also using OSPFv3, HOMENET, resource directories,
and 1-Wire



1-Wire Sensors on the IPv6 Internet



activityroom	2001:14b8:400:f3a:10:9625:3901:800
balcony	2001:14b8:400:f3a:10:710b:3901:800
bedroommaster	2001:14b8:400:f3a:10:6657:3901:800
bedroomjanne	2001:14b8:400:f3a:10:9cd7:3901:800
bedroommelli	2001:14b8:400:f3a:10:ccef:3901:800
circuitbreakercabinerk1b	2001:14b8:400:f3a:10:256d:3901:800
communicationscloset	2001:14b8:400:f3a:10:1317:3a01:800
diningroomeast	2001:14b8:400:f3a:10:8e3:3801:800
diningroomwest	2001:14b8:400:f3a:10:b609:3a01:800
entrance	2001:14b8:400:f3a:10:2c8b:3901:800
ethernetswitch	2001:14b8:400:f3a:10:3598:3901:800
fileservdisk	2001:14b8:400:f3a:10:29a9:b501:800
kitchen	2001:14b8:400:f3a:10:e207:3a01:800
konehuoneserver	2001:14b8:400:f3a:10:eea3:ed01:800
livingroomeast	2001:14b8:400:f3a:10:7de6:3901:800
livingroomtvcorner	2001:14b8:400:f3a:10:e51e:3901:800
owhub	2001:14b8:400:f3a:10:c7e0:3901:800
router	2001:14b8:400:f3a:10:fe71:3901:800
secondutilityroom	2001:14b8:400:f3a:10:ee26:3901:800
storageroom	2001:14b8:400:f3a:10:1ea7:3901:800
storageroomnearthgarage	2001:14b8:400:f3a:10:d03d:3901:800
studyroom	2001:14b8:400:f3a:10:ad13:3a01:800
technologysshaft2nd	2001:14b8:400:f3a:10:10b2:ed01:800
technologyroom	2001:14b8:400:f3a:10:5713:3901:800
technologysshaft	2001:14b8:400:f3a:10:c51:3901:800
terrace	2001:14b8:400:f3a:10:2deb:3901:800
toaster	2001:14b8:400:f3a:10:bb84:b501:800
ventilationusedairout	2001:14b8:400:f3a:10:1bb5:ed01:800
ventilationfreshairtorooms	2001:14b8:400:f3a:10:7ee7:ed01:800
ventilationfreshairin	2001:14b8:400:f3a:10:dadf:ed01:800
ventilationusedairback	2001:14b8:400:f3a:10:f56:3901:800
weatherserver	2001:14b8:400:f3a:10:89b7:3901:800

Feel free to try COAP to these addresses, e.g., kitchen.objez.net

Avoiding Legacy

Using NAT64



IPv6-Only Networking



Without IPv4 for 2.5 years now – happy
We did this for testing our (then) early product, eating our own dogfood, and to prepare the way for others

Three sites were involved:

- › ER NomadicLab, my home, mobile



Experiences (RFC 6586)

The bottom line:

- › IPv6-only was possible; I did not have to go back
- › Some pain was involved
- › Some things **do** break
 - Lack of IPv6 support and previously unseen bugs
 - Some users went back to dual stack due to Skype
 - Key is is true IPv6 support, not so much NAT64

Plenty of effort in the world in last two years to improve the situation

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



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