



Aalto University
School of Science
and Technology

Wireless Networks Unplugged

Jukka Manner with Jörg Ott, Marko Luoma and Jyri Hämäläinen
Professor, PhD.

Aalto University

Department of Communications and Networking

Aalto University?

- Merger of three largest universities in their fields in Finland
 - Helsinki University of Technology (TKK, HUT)
 - Helsinki School of Economics (HSE)
 - University of Art and Design Helsinki (Uiah)
 - Technology + business + design => Aalto
 - Effective 1.1.2010 (104 days old)
 - Web site: www.aalto.fi
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Problem

No verified solution

Drafting things that
could be done

Lot of work done on
energy efficiency







Somewhat little on
those, yet

Ad-hoc networks,
offices, homes,
computing equipment,
buildings,
smart grids,

...

Our focus



?



In particular



Who cares?

We all do

24/7

2G

3G

3. 5G

4G

(LTE, sometime)

Coverage

$$2G = n$$

base stations

$$3G = 2^{-4} \times n$$

$$3.5 \text{ G} = 6-9 \text{ x n}$$

$$4G = 11-40 \times n$$

Huge increase
in network devices

Energy consumption

2G base station ~
0.5-1 kVA

3G ~ 1-2 kVA

4G ~ 1.5-3 kVA

2G \rightarrow 4G ~
30-100 x energy

Power



Technology

Curve for 1 operator

Finland has
3
major operators for
5 million people

Germany:

?

major operators for
82 million people

EU:

?

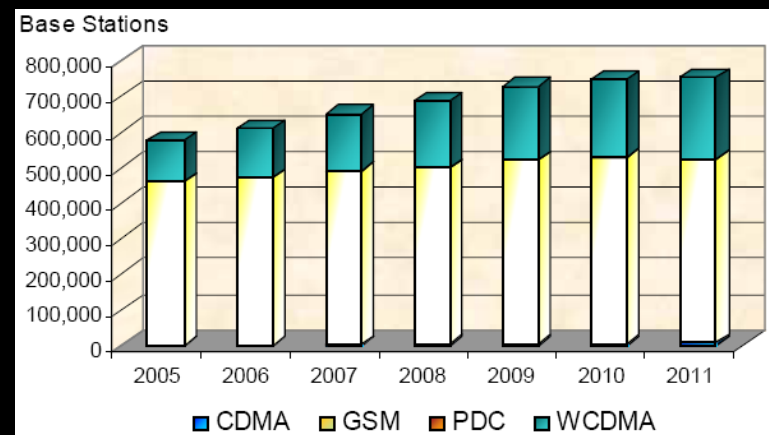
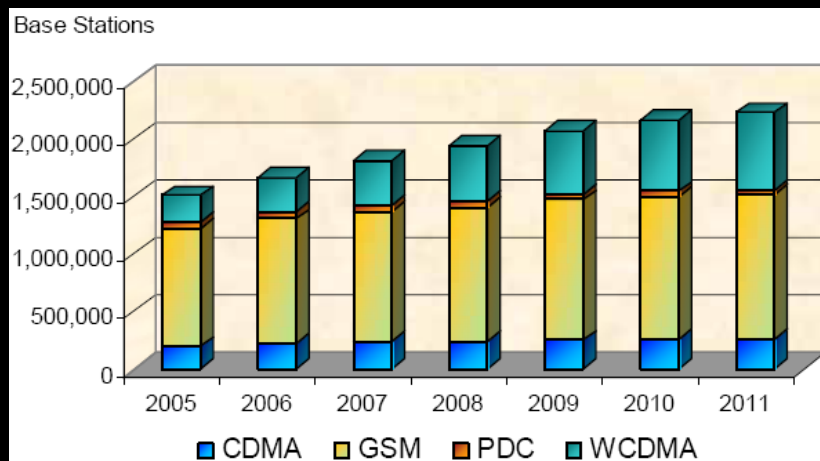
major operators for
501 million people

Issue is
world-wide
energy consumption

Deployed Base Stations		2005	2006	2007	2008	2009	2010	2011	'06 - '11 CAGR
Units									
CDMA		200,054	220,083	238,406	247,826	254,328	258,146	261,288	3.5%
y/y growth			10.0%	8.3%	4.0%	2.6%	1.5%	1.2%	
GSM		1,018,287	1,088,306	1,137,507	1,163,048	1,216,036	1,246,016	1,251,914	2.8%
y/y growth			6.9%	4.5%	2.2%	4.6%	2.5%	0.5%	
PDC		59,898	55,860	51,029	46,597	42,530	41,296	41,315	-5.9%
y/y growth			-6.7%	-8.6%	-8.7%	-8.7%	-2.9%	0.0%	
WCDMA		231,287	302,762	389,808	491,128	562,574	620,404	676,499	17.4%
y/y growth			30.9%	28.8%	26.0%	14.5%	10.3%	9.0%	
Total		1,509,526	1,667,011	1,816,751	1,948,599	2,075,468	2,165,862	2,231,015	8.1%
y/y growth		10.1%	10.4%	9.0%	7.3%	6.5%	4.4%	3.0%	

Source: In-Stat, 02/07

Worldwide total deployed base stations (units). Source: [InStat (2007)]



Total deployed base stations (units), worldwide [left], Europe [right]. Source: [InStat (2007)]

[InStat (2007)] InStat: "WCDMA Base Station: Embracing the New Generation," InStat analyst report by F. Guan, Feb. 2007.

In Europe these cost
today

~ 10 TWh/year

(without 4G and with bad coverage)
(probably way underestimated)

Not just about being
green

Also
OPEX

“Electricity bill is
20% of OPEX today”

(a telco high executive)

Also
site building

A new site needs
power and
cables (x 2)

Digging the cables is
expensive
and sometimes
impossible

Could be build
base station sites
without cables,
communications nor
power?

Unplug Mobile Networks

Examples already exist







Works when you have
ample sunshine and winds

Could also use diesel
generators







Drafting the concept

Background questions

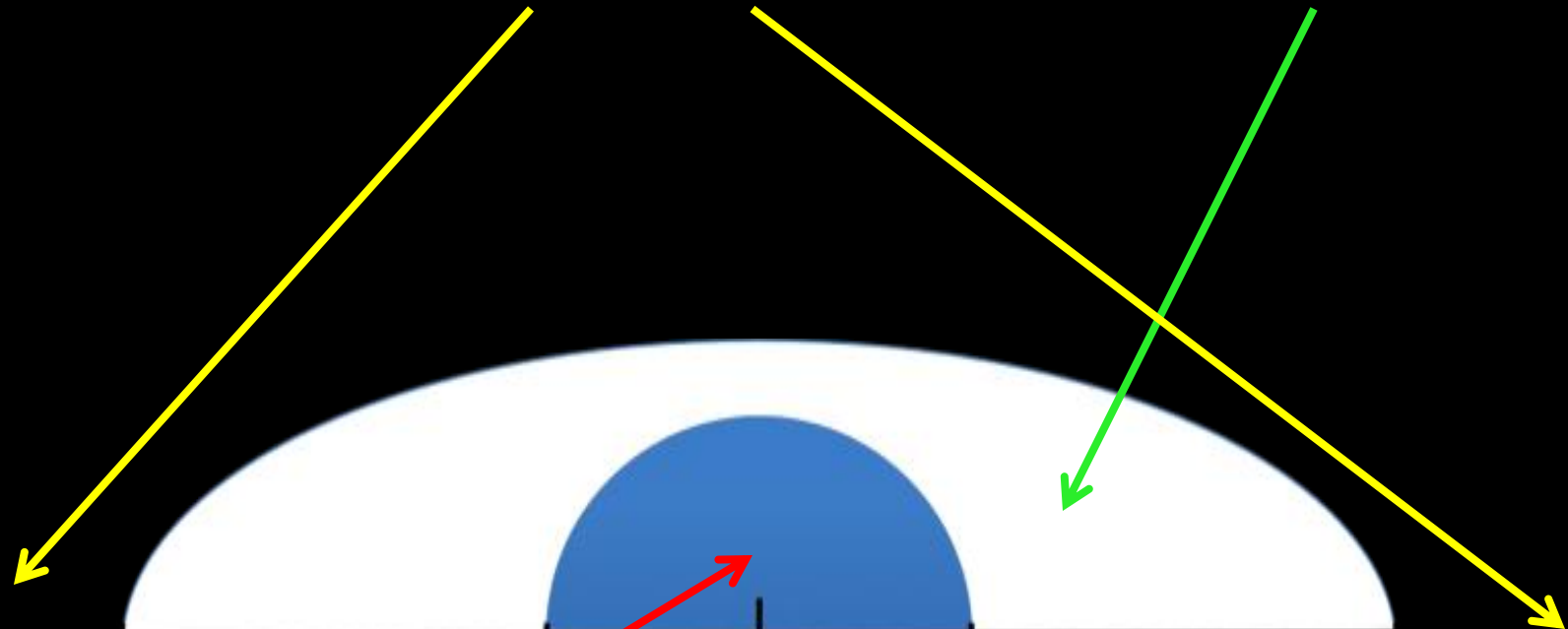
How much energy can be
acquired from
renewable sources?

Deployment locations?

What is the expected
client load?

Little
users

More
sparse



Distance

Densely
populated

Answers differ
between
countries and
regions

10

things that could be
done

1. Better renewable energy sources

2. Better energy
storage, e.g.,
regenerating
fuel cells

3. Development of HVDC powering solutions

4. Envelope tracking,
tight integration of
power amplifier and
radio load

5. Power control, incl.
beam forming, of radio
(lower at the base station, higher at the terminal?)

6. Load balancing

(difficult processor sharing)

7. Deploy black nodes

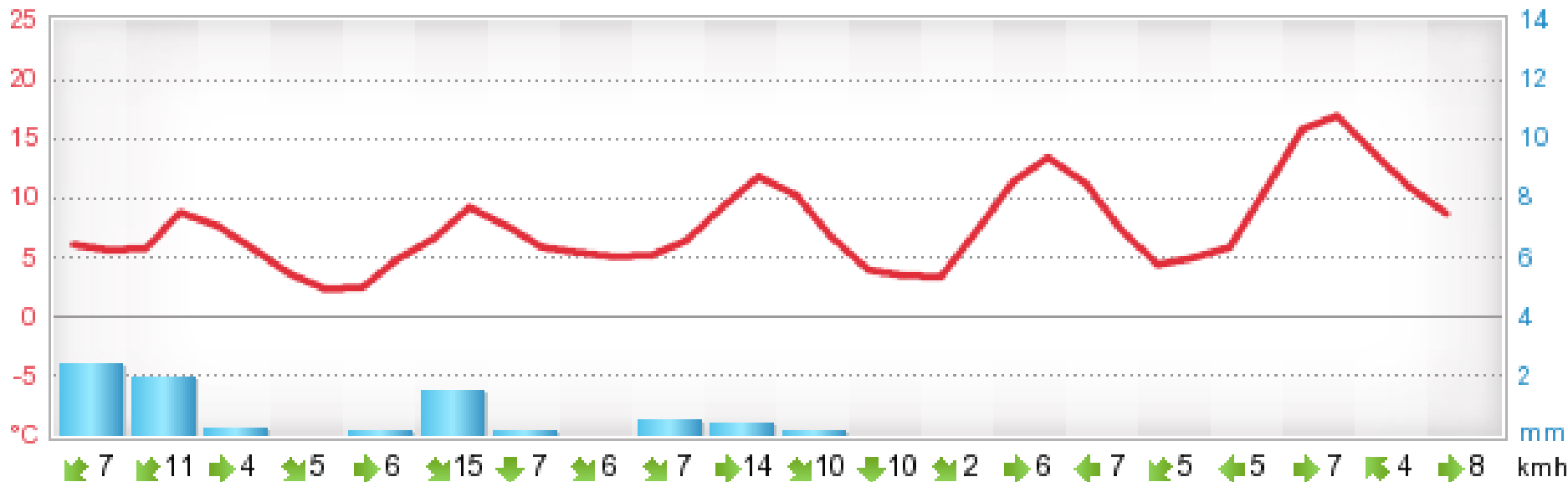
(nodes that regenerate when others operate)

8. New network structures and coverage planning

9. Shutdown
higher speed services

10. Follow weather
forecasts

Wed			Thu			Fri			Sat			Sun			Mon	
14.4.			15.4.			16.4.			17.4.			18.4.			19.4.	
08	14	20	02	08	14	02	08	14	02	08	14	02	08	14	02	08



11. -20. You choose

In summary

Important problem

We can do more than just
lower the consumption

Make it

