Plan of the presentation

- DAB/DAB+ infrastructure
- Some figures for professional setup
- Software Defined Radio and Open tools
- Demonstration
- Discussion
DAB+ infrastructure
DAB/DAB+/DMB transmission infrastructure

Source: www.worlddab.org
Infrastructure

- Encoder: create the DAB+ HE-AAC audio stream
- Ensemble Multiplexer: Gather all the streams (+data)
- Modulator: Create the digital radio signal
- Amplifier: pump up the jam ;-)  
- Mask Filter: to meet BAKOM spectrum requirements
- Antenna: radiate the jam
- + communication lines (STL) between studio, multiplexer and transmitter sites

For single frequency network of many transmitters, add:
- GPS synchronisation clocks
DAB+ professional setup
## Typical prices for professional equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Professional</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAB+ Encoder</td>
<td>~4000€</td>
</tr>
<tr>
<td>Transmission to operator</td>
<td>Leased line: 500-1500€/month</td>
</tr>
<tr>
<td>DAB multiplexer</td>
<td>~15'000€</td>
</tr>
<tr>
<td>Modulator</td>
<td>~10'000€</td>
</tr>
<tr>
<td>250 Watt effective amp</td>
<td>~20'000€</td>
</tr>
<tr>
<td>Mask Filter</td>
<td>1500-2500 €</td>
</tr>
<tr>
<td>Antenna</td>
<td>500 € (dipole) - 2000 € (panel)</td>
</tr>
</tbody>
</table>
Typical price for professional sites

Investment:
- Small site (~500W) : ~ 50’000 €
- Big site (>1kW) : 120’000 €
- + accessories (mast, etc)
- + installation
- + engineering, bakom, ORNI/NIS

Running costs
- Rent, Electricity, Cooling
  - Typical for an operator: 2000-10’000 Frs/month
Professional solutions

- High Investment & Operational costs (CAPEX/OPEX)
  - Increase with the number of sites and SFN
- But division by the number of stations
- Finally turns out to be cheaper than FM for national or big broadcasters

- Often not affordable for local/community/non-commercial broadcasters
- Proprietary solutions
- Operator solution not easily scalable
Digital radio broadcast, far too complex/costly for small radios or experimenters?
It may not be the case anymore...
Software defined radio
Traditional approach of radio transmission/reception

- Specific dedicated hardware
- Low volumes, high prices
- Limited flexibility
- Few possibilities of evolution
Software Defined Radio (SDR) Principle

- Software (de-)modulation
  - Can run on a standard PC platform

- Generic hardware
  - « Like a soundcard » but for radio waves

=> High flexibility, limited by CPU/Interface
PC platform nowadays

- Powerful enough to perform live encoding, multiplexing and complex modulation (COFDM) on a single PC
- High speed interfaces
- Incredibly low price considering the complexity and processing power
A great blackbox!
Democratisation of Software Defined Radio

- **USRP**: Universal Software Radio Peripheral
  - Open hardware solution sold by Ettus for 700$
  - Schematics, FPGA code available to the public
  - Can transmit or receive signals up to 15MHz BW
USRP: Universal Software Radio Peripheral

Baseband complex samples (I/Q)

RF

Receive Daughterboard
- ADC
- ADC

FX2 USB 2 Controller

Transmit Daughterboard
- DAC
- DAC

FPGA

Receive Daughterboard
- ADC
- ADC

Transmit Daughterboard
- DAC
- DAC
What you can do with the USRP and a PC

- FM RDS transmission and reception
- DAB/DAB+ transmission (CRC-mmbTools)
- DRM/DRM+ transmission/reception (Spark, Dream)
- DVB standards, possible but no open projects yet
- Local GSM Network (OpenBTS project)
- GPS receiver
- Aircraft beacon receiver
- Passive Radar
- DECT, RFID, Wifi, etc
SDR projects for broadcasting
DAB Software Radio

- Developed by Communication Research Center (CRC), Canada
  - Francois Lefebvre, Pascal Charest
  - First public demo at IBC2006
  - Presented to WorldDMB TC, Eindhoven 09/2006

- CRC-DABMUX: DAB/DAB+/DMB Multiplexer
- CRC-DABMOD: DAB Mode II OFDM modulator (no SFN)
- Other tools for slideshow, CELT, DAB+, etc
- Open sourced in 2009-2010 (GPL license)

http://mmbtools.crc.ca
Opendigitalradio.org

- **Warning!**
  These tools are **not** turnkey solutions

- Experimental

www.opendigitalradio.org:

- Document experimentations on digital radio broadcasting using open tools and hardware techniques
Spark

- DRM/DRM+ encoder/multiplex/er/modulator
- Not Free/Open but trial and licensed versions (windows)
- http://www.drm-sender.de
Demo!

Encoding, multiplexing, modulating, transmitting 12 DAB+ live programme
Practical cases with DAB and CRC mmbtools
Application: Performance at Label Suisse festival

- Live local broadcasting of 8 DAB channels
- Audio from a video projection of 8 music bands playing
- First licensed DAB transmission fully open source
Application: Performance at Label Suisse festival

- DAB transmission by Maxxima
- Video projection by MXLab

More information on http://www.opendigitalradio.org
Integrating open source blocks on Linux

- JACK
  - PCM
  - TOOLAME & CRC ENCODERS
  - MPEG
  - CRC-DABMUX
- USRP
  - USB
  - BASEBAND PLAYER
  - IQ
  - CRC-DABMOD

ETI
Application: Multiplatform & Hybrid Radio demo

- Generation of DAB (+Slideshow), FM RDS, DRM broadcast signals
Application: EBU Multiplatform Hybrid demo at IBC
DAB/DAB+ (and FM, DRM, streaming) in a box
Hardware for local DAB/DAB+ transmission

10W ERP

PC
- DAB audio Encoder
- DAB Multiplexer
- DAB Modulateur
  - Mask filter
  “Software Radio”

USRP

AMPLIFIER

MASK FILTER
(High Power)
Application: The EBU demo at IBC 2010

- Local DAB coverage at IBC
- DAB/DAB+ live and DMB pre-recorded
- Equipment for DAB transmission:
  - PC: ~800€
  - Linux, gnuradio, CRC-mmbTools: 0€
  - USRP + RF frontend: 1150$ (~820€)
  - Amplifier 35 Watts CW, 6W OFDM: ~ 150€
  - VHF Mask Filter, 6 cavities: 1300 €
  - VHF 5dB 3 elements Antenna: 300€
  - Small equipment: 100€
  - TOTAL: ~ 3500 €
Under development

- Higher power transmission for coverage of a city
- Temporary digital licence (Maxxima radio project)

600W (CW) class AB amplifier development (by Stan Roehrich Maxxima.org)
Amateur radio DRM trial in Sottens using Spark

- 4.5kHz, Mode B, MSC 16QAM, EEP code rate 0.5, AAC audio at 4.8kbit/s
- 4.5kHz, Mode B, MSC 64QAM, EEP code rate 0.5, AAC Audio, MOT Slideshow at 2.56 kbits/s
Great, I want to build my digital radio bouquet over my city tomorrow! How to?
Possibilities for real DAB+ local Ensemble
Software Defined Radio benefits

- SDR lower the costs by shifting to generic hardware
- Enable flexible multiplatform transmission (and reception)
- Still experimental but this could change rapidly...
Implications in the longer term

- Digital Broadcasting transmission gets democratized
- Enabling innovation, local broadcasting, etc
- Lowering costs

What do commercial solutions offer then?

- Turnkey solutions
- Quality hardware for RF transmission (amplification, etc)
- Service and support
- Sophistication (user interface, special features)
Some examples from the past

- **FM**
  - Used for broadcasting since 1955
  - Democratisation in the eighties => community radio explosion (many of them became today’s big private radio groups)

- **Audio**
  - From separate instruments/effects to software plugins
Reality

- Experimental, THIS IS NOT A TURNKEY SOLUTION
  Further work needed to test it 24/24, improve tools
  No SFN solution

- Mixed solutions with professional equipment possible
  - Total DAB in Ireland: CRC MUX + pro. modulator/amp
  - Kanal Plus in Denmark: CRC MUX and MOD, pro amp

- Costs are divided by the number of participants in a mux.

- Public/private digital radio:
  Big networks (many transmitters), SFN
  High availability redundant systems => expensive

- Community radio:
  Local
  Can live with lower reliability (as for streaming)
Example of figures (estimation !)

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<th>Professional</th>
<th>Open/SDR approach</th>
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<tbody>
<tr>
<td>DAB+ Encoder</td>
<td>~4000€</td>
<td>500€ or 2000€ unlimited number of programs</td>
</tr>
<tr>
<td>Transmission to operator</td>
<td>Leased line: 500-1500€/month</td>
<td>Internet stream 50-100€/month</td>
</tr>
<tr>
<td>DAB multiplexer</td>
<td>~15’000€</td>
<td>Free (E1 card for pro. modulator: 1000€)</td>
</tr>
<tr>
<td>Modulator</td>
<td>~10’000€</td>
<td>Free, USRP set: 1500$</td>
</tr>
<tr>
<td>1 kiloWatt effective amp</td>
<td>~20’000€</td>
<td>= (Not done yet)</td>
</tr>
<tr>
<td>Mask Filter</td>
<td>1500-2500 €</td>
<td>= (Not done yet)</td>
</tr>
<tr>
<td>3 elements antenna</td>
<td>500 € (dipole) - 2000 € (panel)</td>
<td>Plumbing costs ;-)</td>
</tr>
</tbody>
</table>
Conclusion

- We believe Digital Radio is now possible for local, community stations (technically)
- Creation of small digital islands instead of big regional coverages

We have not spoken of political aspects
- License, Spectrum access
- Market regulation, competition
Are you ready?