DVB-C2: Ready – PlugFest - Go

System Overview and State of Introduction

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Institut für Nachrichtentechnik

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15. ITG Fachtagung für Elektronische Medien,
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Customers continuously ask for more bandwidth and new compelling services

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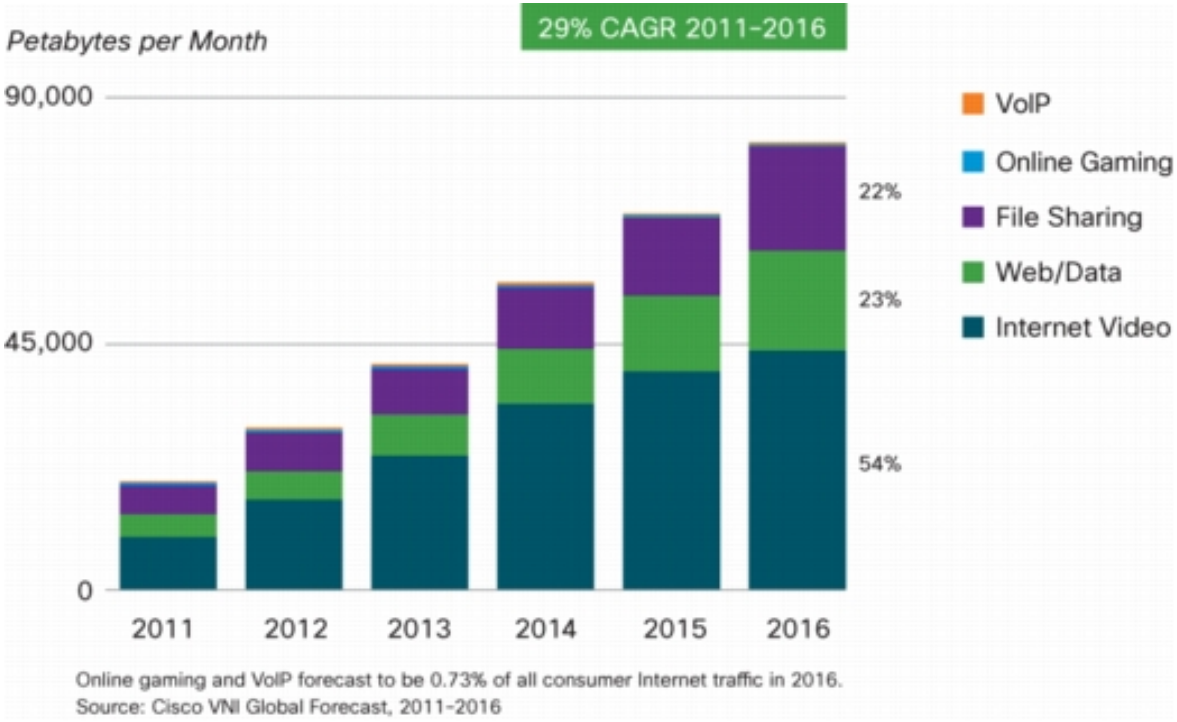
- Current status: Digital Cable can provide up to 5 Gbit/s downstream capacity using DVB-C technology



- Cisco forecasts 32% annual growth of IP traffic in Europe over the next four years
- The ratio of downstream to upstream IP traffic is permanently increasing and currently already higher than 8 : 1
- Access to video is key for cable customers
- The efficient usage of the limited frequency resources is essential for cable operators

DVB-C2: The key technical parameters

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- Highest spectrum efficiency
- Wide range of solutions for all kind of cable networks
- Future proof solution, with headroom for enhanced cable networks
- Flexibility, support of MPEG Transport-Stream and IP-protocol
- Integrated into the family of second generation DVB transmission systems

- ETSI: EN 302 769 (Specification), TS 102 991 (Implementations Guidelines)

	DVB-C	DVB-C2
Input Interface	Single Transport Stream (TS)	Multiple Transport Stream and Generic Stream Encapsulation (GSE)
Modes	Constant Coding & Modulation	Variable Coding & Modulation and Adaptive Coding & Modulation
FEC	Reed Solomon (RS)	LDPC + BCH
Interleaving	Bit-Interleaving	Bit- Time- and Frequency-Interleaving
Modulation	Single Carrier QAM	COFDM
Pilots	Not Applicable	Scattered and Continual Pilots
Guard Interval	Not Applicable	1/64 or 1/128
Modulation Schemes	16- to 256-QAM	16- to 4096-QAM

DVB-C2: Milestones of the DVB project

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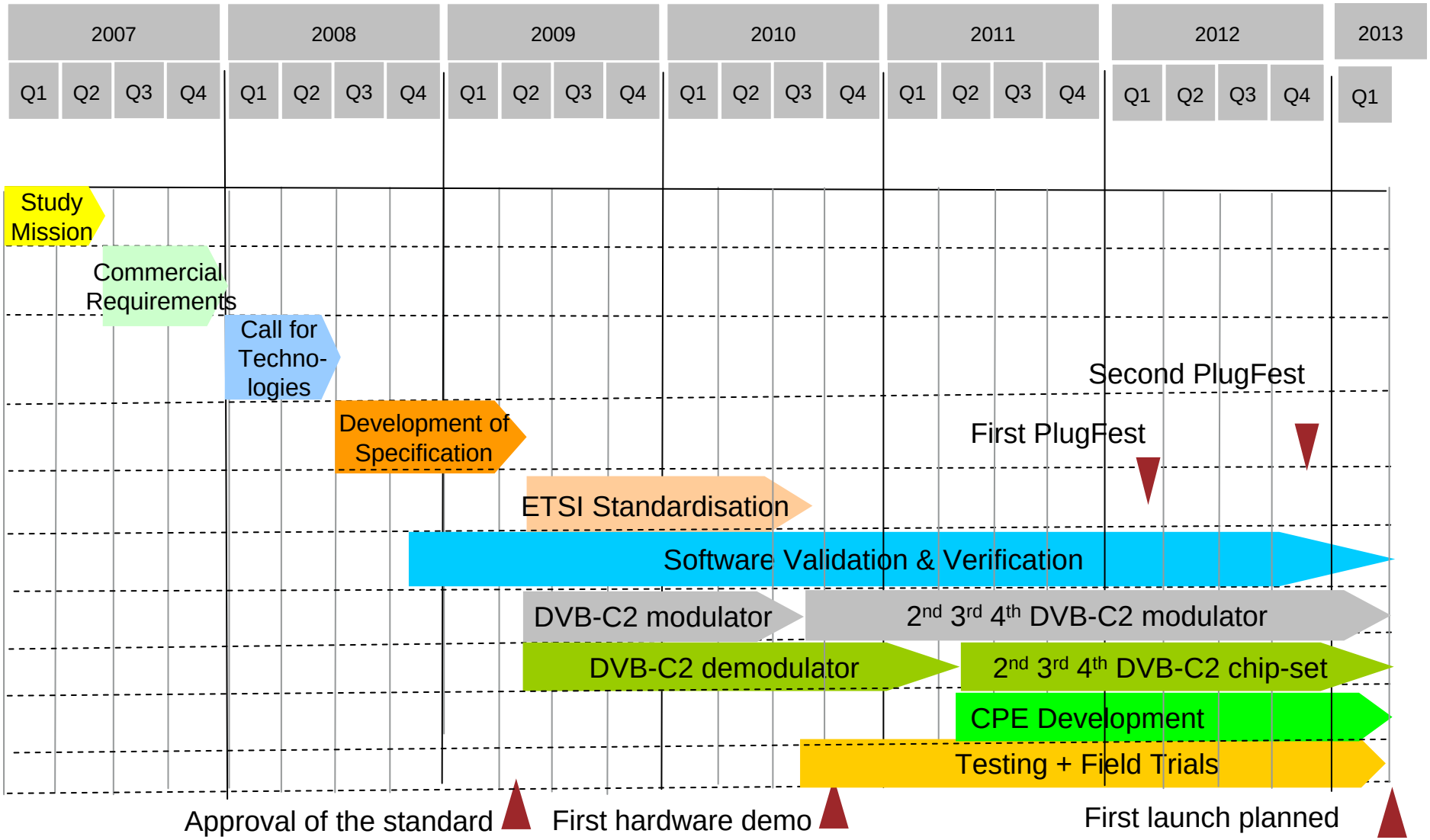

Superb performance of OFDM / LDPC

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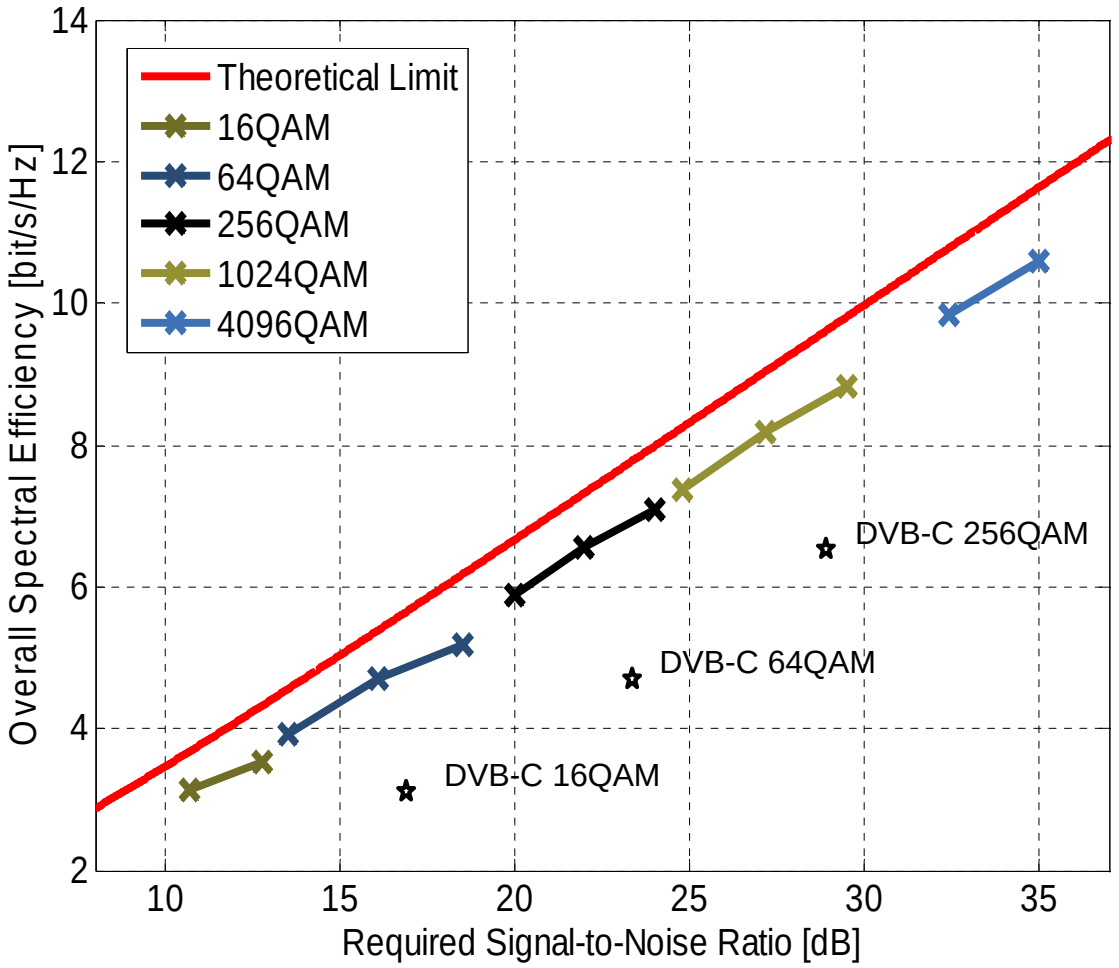
- Close to the theoretical Shannon Limit
- Broad range of solutions for all kind of CATV networks characteristics
- Headroom for optimized HFC networks
- Hooks for future extensions
- Service related QoS possible
- Adaptation of modulation parameters on frame by frame basis possible



Criteria for the cable operator's choice

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- **Increased robustness**:

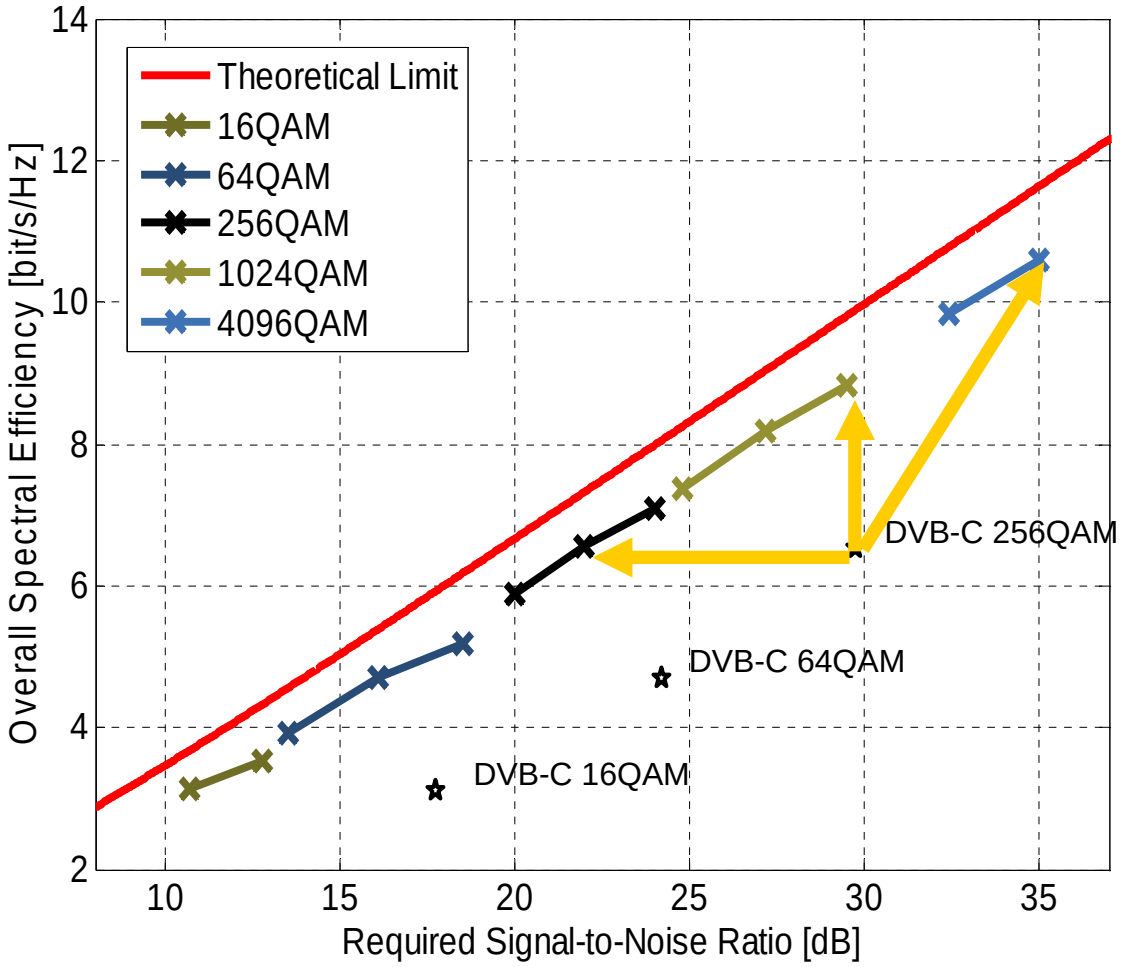
  7 dB

- **Increase of spectral efficiency:**

  36 %

- **Gain of spectral efficiency in modern HFC networks:**

  up to 63,5 %



The process from specification to silicon

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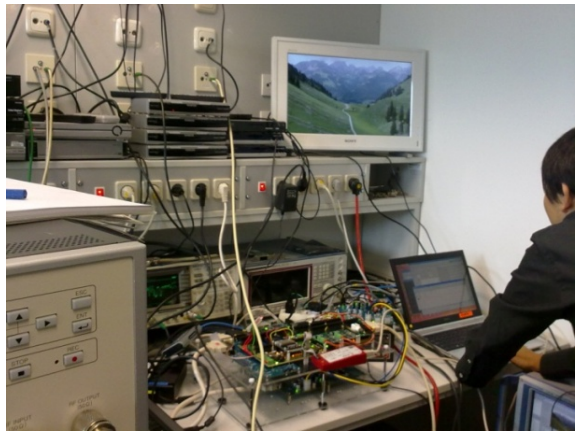
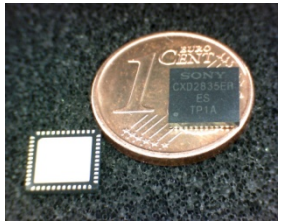
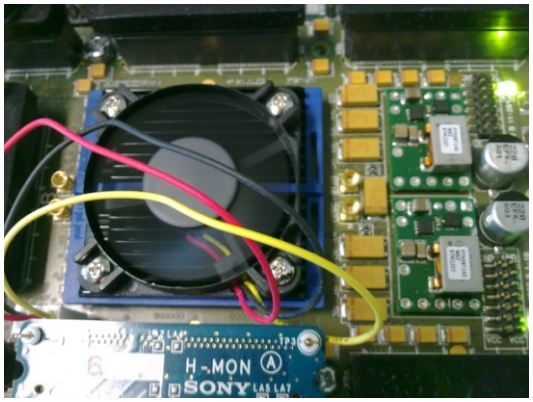
- Software implementation of DVB-C2 in the Verification & Validation Task Force
- Start of a development project for an DVC-C2 FPGA (Sony)
- September 2010: First 4096-QAM transmission in a fully loaded CATV
- October 2010: Evaluation and performance testing of the FPGA
- Sony starts the final chip design process
- April 2011: First samples of the demodulator chip available
- May 2011: First prototype CPE presented at ANGA Cable in Cologne







First 4096-QAM transmission in fully loaded CATV network in Berlin, September 2010

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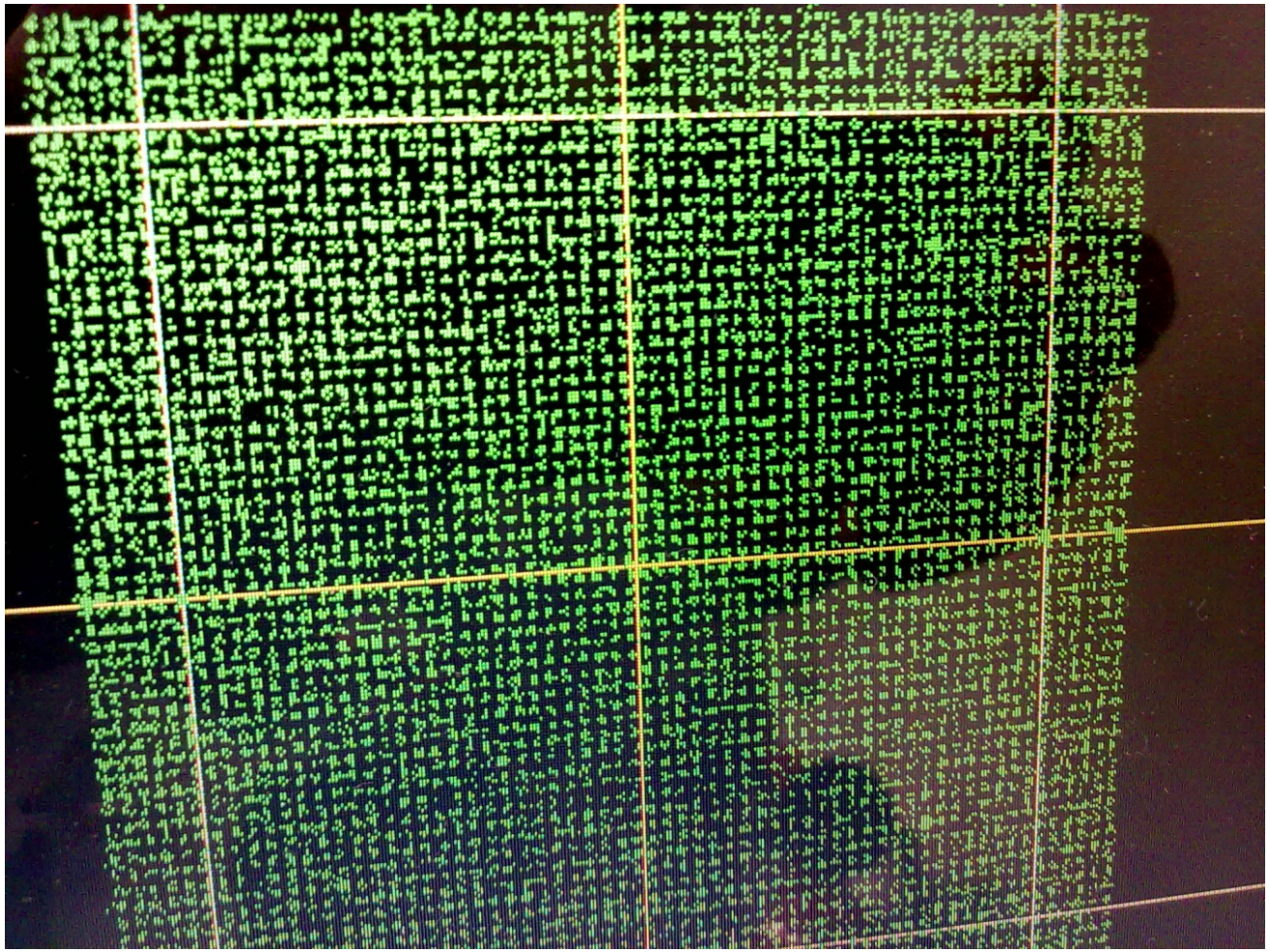

4096-QAM:

64 horizontal

x

64 vertical

constellational points

Provides high spectrum efficiency:
12 bit/s / Hz (gross)
10.8 bit/s / Hz (net)

Requires high Signal-to-Noise-Ratio:

>35 dB

First DVB-C2 Plug Fest on 27th – 29th February 2012

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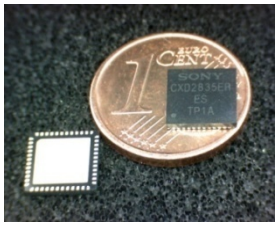
- 4 modulator and 9 receiver implementations tested
- 5 Measurement sessions (>1.100 Tests)
  - Session 1: Interoperability
    - 99 test configurations based on V&V test cases
  - Session 2: Receiver implementation loss
    - Overall performance testing
  - Session 3: Receiver noise sensitivity + input system load testing
  - Session 4: Frequency linearity testing
  - Session 5: Adjacent channel interference testing
    - Selectivity requirements
    - DVB-C2 versus DVB-C2, and versus DVB-C
    - DVB-C2 versus Analogue TV (PAL)

The second DVB-C2 Plug Fest on 27th - 29th November 2012



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- Interoperability testing of 4 different demodulator implementations
  (3 chip designs and one software implementation)
  versus 5 different modulator implementations
- 9 different prototype receivers (tuner/demods) have been evaluated

Significant performance improvement from the first to the second PlugFest

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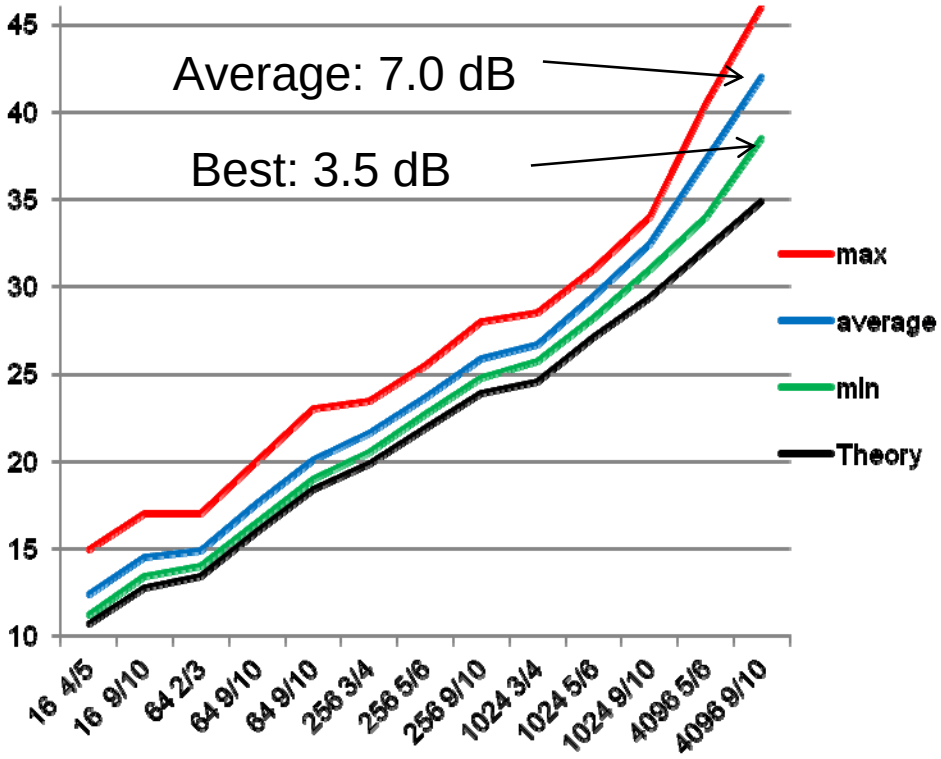
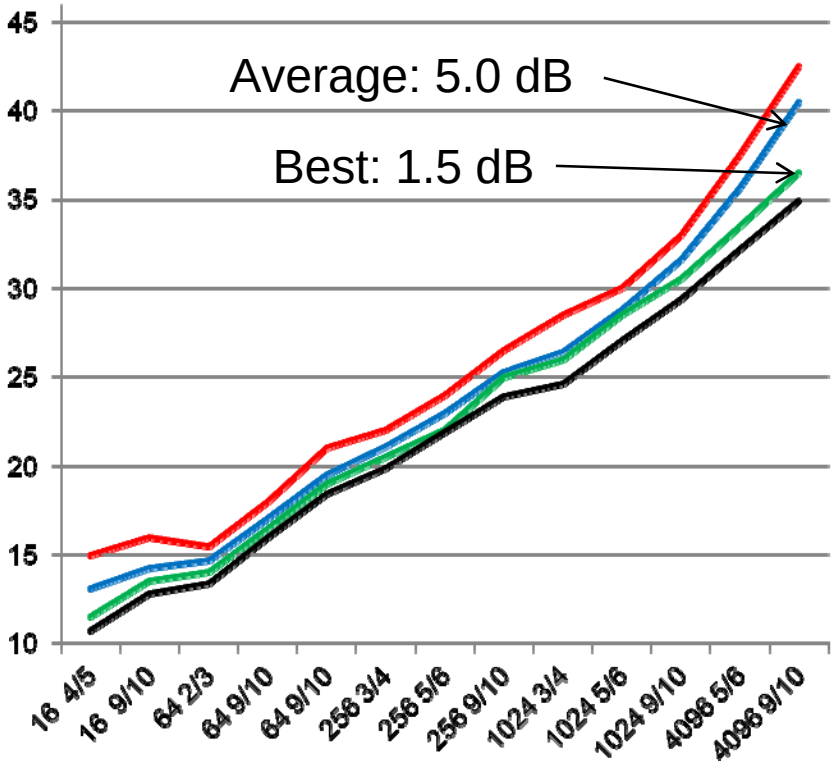
Overall implementation loss



First DVB-C2 PlugFest

Overall implementation loss



Second DVB-C2 PlugFest

Both sets of graphs show the minimum CNR required for error-free video reception

DVB-C2 equipment @ ANGA Cable 2012

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- Sony is in mass production with both DVB-C2, DVB-C2/T2 and DVB-C2/T2/S2 (Triple-Demond) chips
- In 50% of the Sony 2012 cable iDTV product line DVB-C2 is integrated
- Broadcom presented first samples of a DVB-C2 receiver demodulator chip at ANGA Cable 2012
- 6 manufacturers of professional equipment are presenting DVB-C2 modulators at ANGA Cable 2012
- A professional DVB-C2 signal generator (R&S) and a first DVB-C2 measurement receiver (PROMAX) are commercially available

Experimental 16,384-QAM transmission at KDG-Labs in Berlin, September 2012

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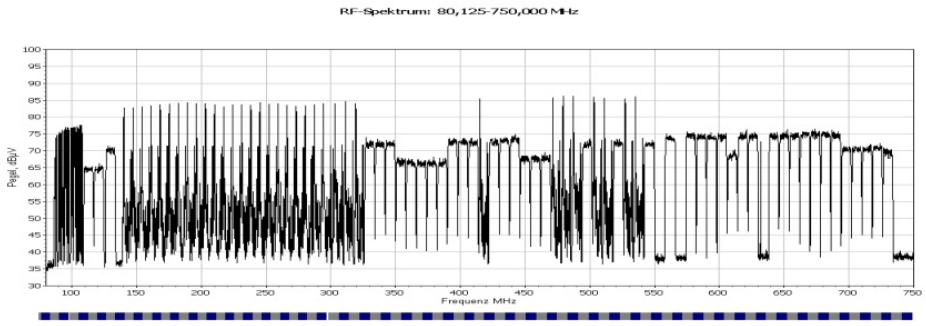
- Fully loaded RFoG network
  - 30 km mono-mode-fibre
  - optical-splitter
  - Fibre-node (optical/electrical converter)
  - Coax- distribution amplifier, coax-splitter, coax-cable, wall outlet

- DVB-C2 @ 16,384-QAM 9/10 FEC code
  - Prototype Modem (DekTec)
  - Payload 93 Mbit/s
  - “Quasi Error Free” at about 45 dB CNR



IFA TecWatch-demo

16,384-QAM constellation diagram at receiver side

Migration to DVB-C2 for HDTV services

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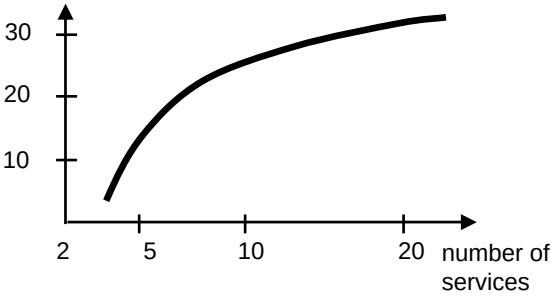
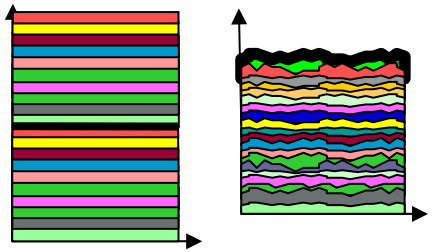
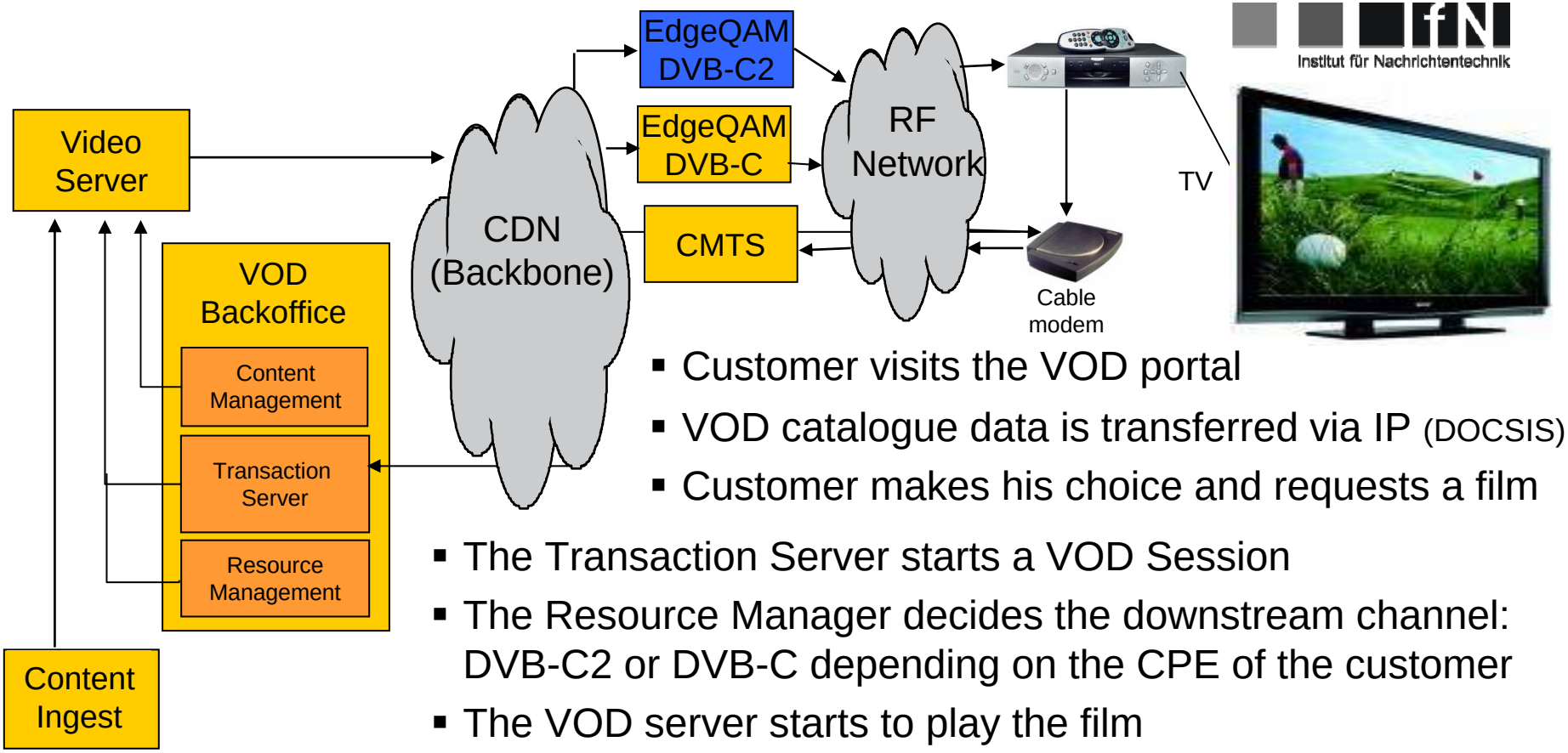
- New tiers of HDTV products are an opportunity for the introduction of DVB-C2 for European cable operators
- Today DVB-C @256-QAM (50 Mbit/s) allows to transport 4 HDTV services using H.264 encoding
- DVB-C2 @4096-QAM, 9/10 FEC, 32 MHz modulator bandwidth (330 Mbit/s) would allow to transport 32 HDTV services using H.264 encoding and providing the same HD picture quality
- Benefit of this solution:
  - 1. about 63% higher spectrum efficiency
  - 2: about 20% higher statistical multiplexing gain
  - **Resulting in an overall 100 % efficiency gain**
  - This solution still works with standard DVB-C2 compatible receivers with a 8 MHz receiver bandwidth





Migration to DVB-C2 for VOD services



- Customer visits the VOD portal
- VOD catalogue data is transferred via IP (DOCSIS)
- Customer makes his choice and requests a film
- The Transaction Server starts a VOD Session
- The Resource Manager decides the downstream channel: DVB-C2 or DVB-C depending on the CPE of the customer
- The VOD server starts to play the film
- The Transaction Server acts according to the customer's commands: pause, fast forwards, fast backwards, ...
- The Transaction Server finally closes the Session

CableLabs has started the DOCSIS 3.1 project: New PHY for Up-/Down-stream

- **DOCSIS 3.1: 10+ Gbit/s downstream and 1+ Gbit/s upstream**
- **Significant cost/bit reductions**
- **Compatibility with characteristics of current cable plants**
- **Backwards compatibility with DOCSIS 3.0**
- **Feasibility of effective migration scenarios**

- DOCSIS 3.1 will be based von OFDM-Technologies
- DOCSIS 3.1 will use LDPC Forward Error Correction (FEC) system
- The specification for downstream signals will be finalized in Q2/2013
- First DOCSIS 3.1 compliant products are expected already in 2014

The HFC structure can meet the market demands far longer than expected up to now : Options and potential extensions of transmission standards

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System configuration	Bandwidth	Payload Capacity	Total Payload Capacity	Gain ref. to DOCSIS 3.0
KDG 2012 field trial EuroDOCSIS 3.0	**96 x 8 MHz**	**96 x 50.7 MBit/s**	**4.870 Gbit/s**	**-**
Option1: DVB-C2 basic (1024-QAM)	**96 x 8 MHz**	**96 x 66.3 Mbit/s**	**6.365 Gbit/s**	**+31 % (+1.5 Gbit/s)**
Option2: DVB-C2 optimized (4k-QAM)	**3 x 256 MHz**	**3 x 2.67 Gbit/s**	**8.01 Gbit/s**	**+64 % (+3.1 Gbit/s)**
Future Option 3*: DVB-C2 (ext. to 16k-QAM)	**3 x 256 MHz**	**3 x 3.15 Gbit/s**	**9.45 Gbit/s**	**+94 % (+4.6 Gbit/s)**
Future Option 4*: DVB-C2 (ext. to 16k-QAM, 1.2 GHz)	**4 x 256 MHz**	**4 x 3.15 Gbit/s**	**12.6 Gbit/s**	**+158 % (+7.7 Gbit/s)**
Future Option 5*: DVB-C2 (ext. to 64k-QAM, 1.2 GHz)	**4 x 256 MHz**	**4 x 3.6 Gbit/s**	**14.4 Gbit/s**	**+195 % (+9.5 Gbit/s)**
Future Option 6*: DVB-C2 (ext. to 64k-QAM, 2 GHz)	**6 x 256 MHz**	**6 x 3.6 Gbit/s**	**21.6 Gbit/s**	**+344 % (+16.7 Gbit/s)**

* These options are currently not available, but are expected to be feasible in future optimised HFC networks

Conclusions: DVB-C2 efficiency and flexibility combined

- DVB-C2 meets the targeted efficiency enhancement and provides headroom for future enhanced cable networks
- Different chip vendors have implemented DVB-C2 demodulators in consumer type chips
  - The mass production of a first chip has started early 2012
  - First iDTVs with DVB-C2 are in the shops since April 2012
- Different DVB-C2 headend products are commercially available
- The DVB-C2 has been carefully validated and evaluated, including two PlugFests with more than 30 different prototype devices tested
- The migration to a new modulation scheme is a challenge for cable operators. However first services will start in about two months time.

Thank you for your attention.

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