Standardization of xDSL and MGfast in ITU-T SG15

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Overview

- About ITU-T SG15 Q4
- xDSL, G.fast and MGfast access solutions
- VDSL2: recent/ongoing enhancements
- G.fast: recent/ongoing/future enhancements
- MGfast: emerging new technology
About ITU-T SG15 Q4

- SG15: Networks, Technologies and Infrastructures for Transport, Access and Home
- Q4: Broadband access over metallic conductors
- Covers all aspects of transceivers operating over metallic conductors in the access part of the network
- Projects: G.xdsl, G.fast, G.mgfast, G.lt (testing), G.ploam (management)
- Main liaisons: ITU-R, ETSI and Broadband Forum
- Meets face to face about 6 weeks per year
Overview Access Network Solutions

G.fast and MGfast fill an access technology gap

- Huge gap 100 Mbit/s ➔ multi Gbit/s
- Fiber may not always be possible into the home/apartment
- G.fast and G.mgfast support FTTdp and FTTB architectures.

Fiber | Copper

VDSL2

Short (<2500m)

CO

CPE

CPE

CPE

CPE

CPE

G.fast

≤ 1..2 Gbit/s

Very short TP or coax (<400m)

MGfast

≤ 5..10 Gbit/s

No drilling
No digging (<100m TP or coax)

Fiber

Copper

≤ 5..10 Gbit/s

≤ 400 Mbit/s (35b)

≤150 Mbit/s (17a)

≤ 25 Mbit/s

≤ 5..10 Gbit/s

≤ 400 Mbit/s (35b)

≤150 Mbit/s (17a)

≤ 25 Mbit/s

≤ 5..10 Gbit/s
VDSL2

• What is in the Recommendations (G.993.2/5, G.993.5, G.998.4)
  – Aggregate data rates up to 150 Mbit/s (17a), 250 Mbit/s (30a), 400 Mbit/s (35b)
  – Operates over loops up to 2500m of 0.4mm copper
  – PHY layer retransmission and crosstalk cancellation (vectoring)
  – Down/up asymmetry ratio depends on band plan used (997 / 998 types)
  – Low power mode (reduced data rate and spectrum when user traffic is low)

• Ongoing work (consented in June 2017 – under approval process)
  – New Annex on mitigation of strong FEXT (operation in high crosstalk cables)
    • Defines a TIGAV procedure to adapt TX PSD under varying high FEXT levels
  – Long Reach VDSL2 (targets 10 Mbit/s over 4km of 0.5mm copper)
    • Defines a line probing during initialization to adapt TX power/PSD to the loop length
    • Adds ADSL2plus techniques for best performance on longest loops
Key Aspects of G.fast

- **Aggregate service rate** (up+down) targets (over 0.5mm copper)
  - 1 Gbit/s at 50m
  - 900 Mbit/s at 100m
  - 600 Mbit/s at 200m
  - 300 Mbit/s at 300m
  - Operates up to 400m

- Far exceeding initial ITU-T performance targets

- Operates over twisted pair, quad cables, and also coax.

- Customer **Self-Installable** CPE

- **Low power consumption modes** and reverse power feeding

- **Robust** with high immunity to disturbers

- **Crosstalk cancellation** for operation in multi-pair cable

- Down/up **asymmetry ratio** is static configuration of TDD split

- **NTR** and **Time-of-Day** support (expected accuracy < 50ns)
Key aspects of FTTdp

• Reverse power feeding (RPF) the DPU from the user premises.

• Persistent Management Agent (PMA) acts as management proxy in the event the DPU loses power.
# G.fast Characteristics

<table>
<thead>
<tr>
<th></th>
<th>G.fast</th>
<th>VDSL2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulation</td>
<td>DMT (up to 14 bits/sub-carrier)</td>
<td>DMT (up to 15 bits/sub-carrier)</td>
</tr>
<tr>
<td>Bandwidth (MHz)</td>
<td>106, 212</td>
<td>8, 12, 17, 30, 35</td>
</tr>
<tr>
<td>Max Transmit Power (dBm)</td>
<td>2 (coax) and 4 - 8 (TP)</td>
<td>11.5 - 20.5 (TP)</td>
</tr>
<tr>
<td>Duplexing</td>
<td>TDD</td>
<td>FDD</td>
</tr>
<tr>
<td>Distance</td>
<td>&lt; 250m (400m) TP</td>
<td>&lt; 1000m (2500m) TP</td>
</tr>
<tr>
<td>Bit Rate (up+dn) (Mbit/s)</td>
<td>&lt; 1000 (106), &lt;2000 (212)</td>
<td>&lt; 400(35b), &lt; 150(17a)</td>
</tr>
<tr>
<td>One way latency</td>
<td>&lt; 1 ms</td>
<td>&lt; 10 ms</td>
</tr>
<tr>
<td>Vectoring</td>
<td>Yes</td>
<td>Optional</td>
</tr>
<tr>
<td>Up/Down Rate Ratio</td>
<td>Provisioned, dynamic</td>
<td>Fixed by bandplan</td>
</tr>
<tr>
<td>Retransmission</td>
<td>Yes</td>
<td>Optional</td>
</tr>
<tr>
<td>Coding</td>
<td>Interleaved RS/Trellis</td>
<td>Interleaved RS/Trellis</td>
</tr>
<tr>
<td>Full init time (single line)</td>
<td>20 seconds (typical)</td>
<td>120 seconds (typical)</td>
</tr>
</tbody>
</table>
Coexistence Issue with ADSL/VDSL

RX is disturbed by time variant FEXT

RX is disturbed by time variant NEXT
Spectral Compatibility

VDSL2 & G.fast

VDSL2 Launched Here

Distribution Point (dp)

Node

Exchange

VDSL 17a Transmit Spectrum

Crosstalk 17

Line 2

Line 1

Crosstalk 17

106

Frequency (MHz)

G.fast Transmit Spectrum

Crosstalk

Line 3

> 17

106

Frequency (MHz)

G.fast Transmit Spectrum

Crosstalk

Line 4

106

Frequency (MHz)

106

Frequency (MHz)

>17

G.fast

Transmit Spectrum

Crosstalk

Line 3

Frequency (MHz)

VDSL 17a

Transmit Spectrum

Crosstalk 17

Line 2

Frequency (MHz)

106

Frequency (MHz)
Collaboration with Broadband Forum

- Long standing collaboration with the Broadband Forum
  - BBF test plans have followed up with the ITU-T DSL standards evolutions on ADSL, ADSL2, ADSL2plus, and VDSL2

- Broadband Forum has been recognized by the ITU-T SG15 as a partner in improving the DSL Recommendations
  - Multi-vendor plugfests (sandbox testing) identify shortcomings

- Broadband Forum certification program
  - Detailed testing of the G.fast technology / functionality
  - Based on ITU-T G.fast specifications G.9700/9701

- Broadband Forum YANG development
  - Interoperability at the VDSL2 and G.fast management interface
  - Based on ITU-T Physical Layer OAM specifications G.997.1/2

- Co-branded ITU-BBF G.fast interop event in the BBF pavilion of BBWF2017
Operation over coax

• Approved April 2017 as part of G.9701 Annex X
  – Operation without coordination across lines
  – 106 and 212 MHz profiles with 2 dBm max TX power

• Use case:
  – G.fast overlay on existing in-building SAT TV coax distribution
Dynamic Time Assignment (i-DTA)

• Approved April 2017 as part of G.9701 Annex T/X
  – Operation without coordination across lines (i-DTA)

• Concepts:
  – AN/DPU system monitors up/down throughput needs
  – Requests FTU-O to change the TDD up/down ratio
  – FTU-O and FTU-R implement the change synchronously and seamlessly
  – Up/down ratio between 5/30 and 30/5 with default 7/28

• Use case:
  – Improve end user experience (QoE) by dynamically allocating the aggregate capacity to the direction that best serves the instantaneous needs of the user’s applications.
NT Software Download

• Approved April 2017 as G.9701 Annex S
  – Software download from DPU over the G.9701 eoc to NT

• Concepts:
  – NT software image gets downloaded to the AN/DPU
  – DPU forwards the NT software image to the NT over the G.9701 eoc
  – Typical software image takes 1-2 sec to send over eoc
  – Protocol based on the G-PON OMCI ONU software download
  – Managed objects defined in support of YANG data model (TBD in BBF)

• Use case:
  – NT is simple device (SFP or PHY adapter without IP address)
Future G.fast work

• Impulse noise monitoring (consented in June 2017 - under approval process)
  – To facilitate characterization and source identification

• Metrics for service rate estimation (consented in June 2017 - under approval process)
  – Attainable throughput estimation (ANDEFTR) under current noise conditions

• Improved UPBO
  – Frequency dependent UPBO, more advanced mechanisms

• Coordinated DTA
  – Dynamic change of up/down split over the vectored group

• Line reconfiguration without retrain
  – Selected set of configuration parameters (e.g., SNRM, MAXNDR)

• Goal to define short TDD frames for delay sensitive applications
  – Radio fronthaul, CPRI transport, Ethernet backhaul
  – Assessing the requirements/need, liaising with 3GPP
Emerging G.mgfast - Multi-Gigabit fast

- G.mgfast is the project defining the MGfast technology
- New project to address functionality beyond G.fast
  - Profiles beyond 212 MHz (e.g., 424 MHz and 848 MHz)
  - Full-duplex operation (echo cancelled mode)
  - Co-exist with G.fast in overlapping frequency bands through mutual vectoring
- Targets
  - Aggregate data rates of 5 - 10 Gbit/s over single TP/coax.
  - Operation over twisted pair, quad and coaxial cable.
  - Consent mid 2019.
- Open points under discussion
  - Topologies: (multi?)point-to-(multi?)point
  - Advanced coding (e.g., LDPC)
  - Multi-stream support for QoS differentiation / 5G slicing
  - Convergence of access and in-home networking
Thank you