Opportunities and techniques for power saving in DSL

ITU SQ15 Low Power Tutorial Session

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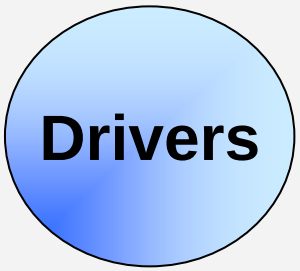
14th February 2006, Geneva

Reminder



- **Social Responsibility**
  - Embraced by corporate leadership
- **Proactive response to climate change**
  - Rational basis for investment
- **Reduce operational costs**
  - Cost of power and carbon is escalating
- **Significant savings possible**
  - 200M+ DSL lines worldwide now still growing fast

Low Power DSL
~ Context for BT

- BT commitment
  - 80% CO_2 reduction by 2016 from 1997 base
- EU Code of Conduct for Broadband Equipment
  - Reduce actual power consumption per line
- Always On
  - High power standby states
- All you can eat
  - Every last bit per second the line will bear
- IPTV
  - Impeccable service stability and effectively error free
- Large legacy investment
  - Expensive to replace

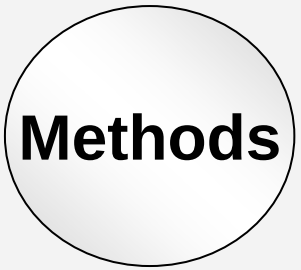
Low Power DSL Requirements ~ top down view

- ***Network Power consumption should be a low as economically feasible and proportional to transmission demands:***
  - Further reduction in power consumption delivered by exploiting Moore's law
    - Smarter specification
  - Power consumption should scale linearly with:
    - Number of active CPE
    - Traffic packets transported
    - Information content of packets
    - Number of control and management events

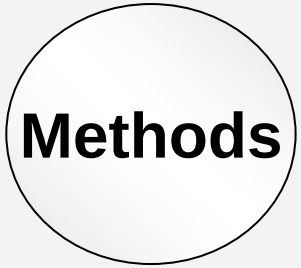
Energy reduction strategies at the PHY layer ~ Reduce Transmitter Power

- Frugal
  - Use only sufficient power to meet transport rate requirement
- Smart
  - Reduce power when there is little or no traffic to carry
- Responsible
  - Turn off when not in use
  - Reduce CPE power consumption

- Assumption
  - The line driver consumes a substantial proportion of overall power dissipation
  - Line driver power consumption scales with actual TX power



Reducing TX Power



- Adaptive start-up
  - Autonomous transmit power reduction when data rate and margin requirements are satisfied.
- ADSL2/2plus L2 mode
  - Supports programmable low power / low rate mode
  - Autonomous up/down shift, driven by traffic demand
- ADSL2/2plus / VDSL2 L3 mode
  - Sleep state waiting for initialisation
- VDSL Profiles
  - Implementations optimised to spectrum management and loop length limitations of various domains

PHY layer tools available ~ Limitations

- Adaptive start-up
  - If a service rate cap can be set, the modem can be commanded to start up with the minimum power required to reach target margin.
  - In many countries the predominant service is based on the ‘up-to’ service model, driven by the residential market.
  - Latest ‘up to 24 Mb/s’ ADSL2plus service drives most lines to maximum permitted TX power
- L2 mode
  - Can produce extreme fluctuations in crosstalk noise that are particularly damaging to IPTV service QOE
  - Can be set to trade off power savings against resulting service instability
  - Designed for traffic transparency but Interaction with higher layers is crude

PHY layer tools currently available ~ Limitations

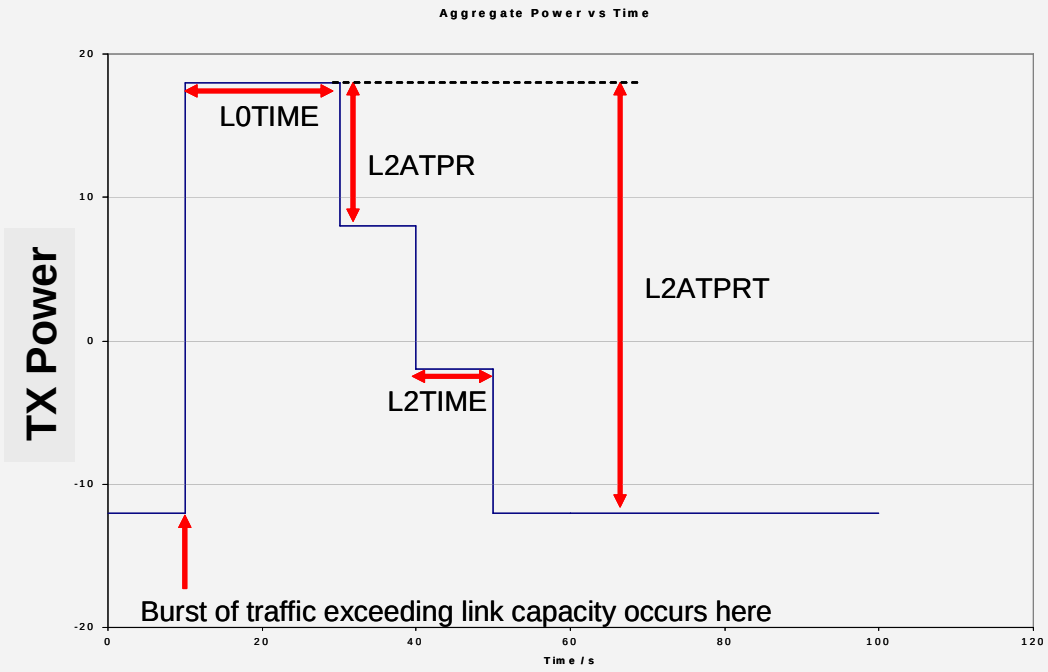
- L2 mode ineffective if max TX power is constrained
  - Due to Spectrum Management rules and/or Cabinet location
- L2 fluctuating crosstalk
  - Can cause violent fluctuations in crosstalk of up to 30dB
  - Lossless packet transfer demands asymmetric power steps – fast increase and slow reduction
- DSP power consumption largely invariant to L2 state
  - No tools to reduce DSP cycles or control processing to exploit traffic statistics

L2 Mode Functionality and programmability

Methods

Description

- When there is little or no traffic, the link runs at low power and low rate
- If traffic demand exceeds the current data rate, link capacity is immediately restored, and TX power returns to nominal.
- When the bandwidth demand reduces, TX power, and data rate, is reduced in steps, until a minimum power level is reached.



Response to a short burst of traffic

Case Study
L2 mode dynamics

Realities

Cross talk simulation

- 19 disturber

Traffic simulation state

- Random inter-arrival time
- Long term average 20 kb/s

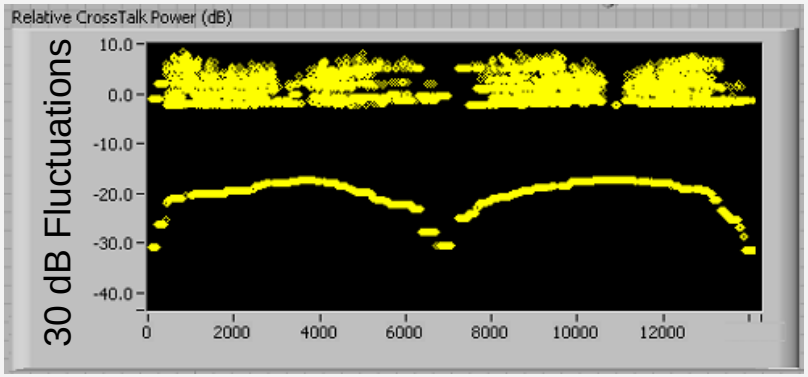
Aggressive L2 setting

- 30 dB steps to 30 dB
- 1 second timescale
- Save of order 200 mW/line

• Polite Setting

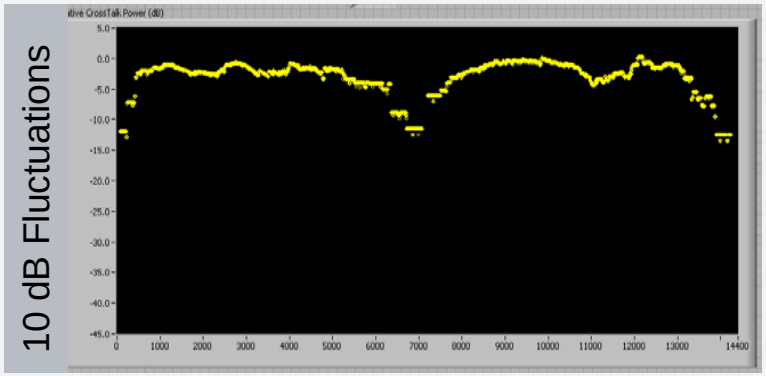
- 1 dB steps to 10 dB
- 127 second time scale
- Save of order 100 mW/line

Aggressive L2 mode settings



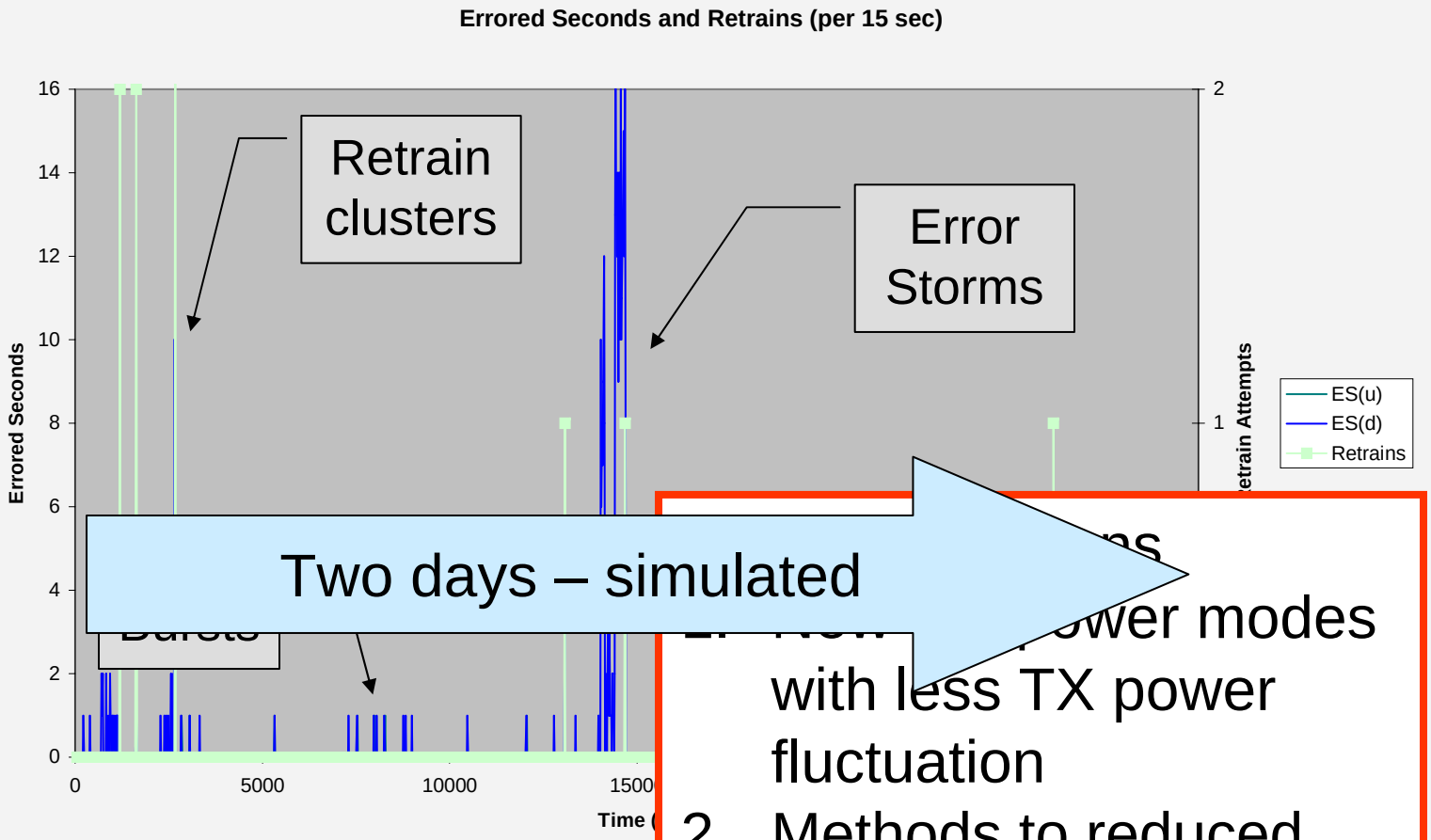
Two daily cycles of activity

Most polite L2 mode settings



Realities

Case Study
~ Impact of L2 mode crosstalk



2. Methods to reduced receiver susceptibility

The Multi-Operator PowerSave Initiative ~ History

- Started Q2/2007
- Objective to press standards bodies and the ITU in particular to deliver solutions to drive down power consumption of broadband
- Involving ATT, KDD, BT, FT, KPN, Swisscom, T-Systems, Telecom Italia, Telia-Sonera, Telenor
- Email group + London workshop in August 2007
- Joint contributions to ETSI TM6, DSLF + ITU Q4/15
- ETSI response positive linked to TM6 work item
- DSL Forum policy agreement to study requirements
- ITU Q4/15 response ~ watch this space

The Multi-Operator PowerSave Initiative ~ Key Requests to ITU Q4/15

- ✓ New annex or annexes for ADSL2 and ADSL2plus with reduced PSD and total transmit power, for equipment designed to be deployed on short lines and from the cabinet.
- New low power mode for VDSL2, ADSL2 and ADL2plus include options for traffic dependent power saving without creating crosstalk fluctuations
- Improvements to L2 mode in ADSL2 and ADSL2plus to enable recovery from low power state to be established in several steps over a period of time.
- Improvements to VDSL2, ADSL2 and ADSL2plus receivers to make them more able to cope with crosstalk fluctuations.
- ✓ Extend virtual noise functionality to ADSL2/2plus
- Study further means for reducing VDSL2 and ADSL2/ADSL2plus power consumptions

Low Power DSL Issues

- **Focus**
  - Implementations with constrained maximum TX power
  - Modes exploiting traffic dependent TX power
  - Modes exploiting traffic dependent DSP cycles
  - CPE interactions
- **Timescales**
  - Development ~ Vendor development exhaustion?
  - Deployment ~ Over optimistic timescales?
  - Rendezvous ~ What is the time window?
  - Fibre verses DSL power learning curve
- **Service requirements**
  - Transparency
  - Service differentiation
  - Cross layer communication

Thank you

- Can we reduce the power consumption of DSL broadband by 50% from 2007 baseline?

Energy saving in DSL Broadband Networks Summary

- Methods available now
  - Moore's law
  - Dynamic Spectrum Management
  - Low power modes
  - DSLAMs close to the customer
- Barriers
  - Analogue interfaces do not follow Moore's law
  - Low transmit power increases DSL's vulnerability to noise
  - Low power modes cause service degrading crosstalk noise fluctuations
- Demand
  - Low power modes for VDSL2
  - New low power modes that do not cause crosstalk fluctuations
  - Improved receiver techniques less vulnerable to noise fluctuations
- The system Issues
  - Instant availability requires high standby power consumption
  - Lowest layers need to be aware of session status
  - Services need to accommodate PHY layer state change latency
- The PowerSave initiative
  - Multi-operator initiative started in 2007 to encourage ITU SG15

DSL Forum agreement:

Globally there are increasing demands for action to contain and reduce the electrical power required to operate broadband networks. This is in light of the need to reduce carbon footprint, and the increasing energy component of operational costs. The DSL Forum has determined to study operator requirements, and how these might be addressed holistically by optimising service, transport, and PHY layer techniques.

The DSL Forum encourages international standards bodies to develop techniques for power reduction within the scope of their activities and to cooperate with the DSL Forum to maximise the savings while preserving and enhancing quality of service.