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Modeling the Channel Capacity for Different Generations of In-Home Data Transmission Systems

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Overview

- Audio-video distribution
- In-Home data networks
- Evolution of cable network concept
- Cable model
- Capacity evaluation
- Results
- Future work
- Conclusions

Audio-video distribution

- Audio-video distribution today
  - Traditional – analog
  - Digital – DVB, IPTV

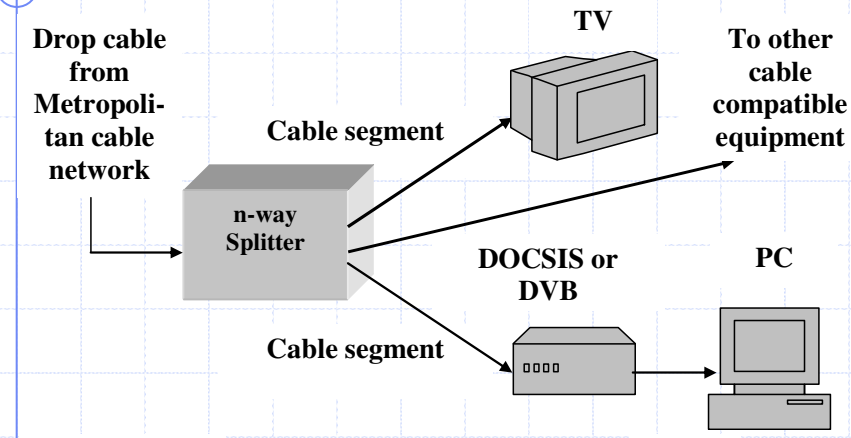
Digital distribution in cable networks

1. Quality of service – better image/sound
2. Enhance the number of channels w/o raising the costs
3. New possibilities- mix A/V and data
4. Reuse the telecom infrastructure – same channel allocation
5. Creates the possibility to implement personalized distribution i.e. Audio-video distribution for specific groups/individuals

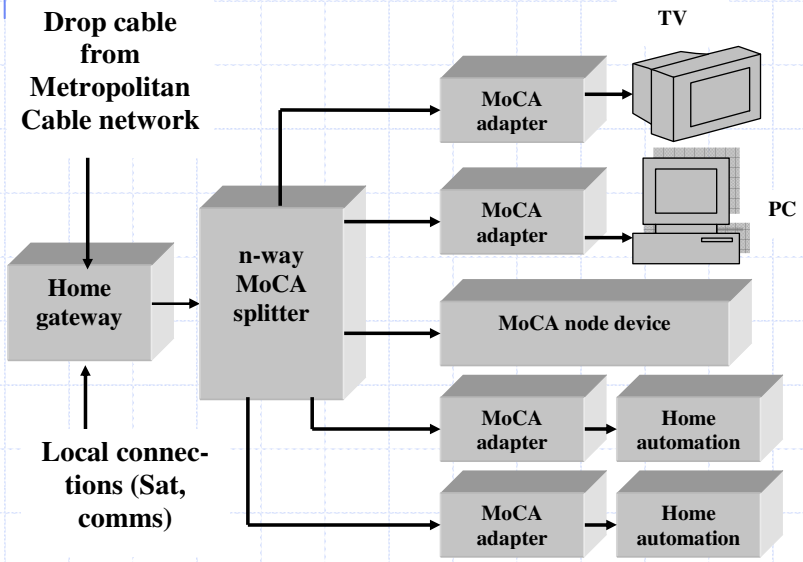
In Home Data Networks

- **Necessity**
  - Synchronization of in-home communications with the growing concept of Smart Home
  - Multimedia information tends to be dominant in modern homes
  - New architectures for audio-video (multimedia) information in homes (Central entertainment servers and multiple clients)
- **Challenges**
  - Rapidly growing data bandwidth for in-home communications
  - A large number of standards to be modified for interoperability

Evolution of cable network concept



Structure of first generation in-home cable network



Third generation in-home network based on MoCA architecture

In-home network - traffic

Service	Bandwidth	Number of Devices	Bandwidtli Residential Gateway
TV	2 to 20 Mbps	3	2 to 54 Mbps
Digital Video Recorder (DVR)	2 to 20 Mbps	1	0
Home Theater	1 to 6 Mbps * Audio	1 System	0
Internet Browsing	1 to 2 Mbps	1 to 5	1 to 10 Mbps
Printer	0.5 to 1 Mbps	1 to 5	0
Digital Imaging	1 to 20 Mbps	1 to 3	0
Digital Idephone	0.2 Mbps	1 to 5	0.2 to 1 Mbps
Online Gaming	0.2 to 1 Mbps	1-3	0.2 to 3 Mbps
Video Capturing	0.1 to 1 Mbps	1-10 * Security Cameras	0
Portable Audio	0.1 to 20 Mbps	1to3	0
Total	70 Mbps to 100Mbps		2 to 60 Mbps+

Necessity is revealed from the next table

Requirements of the in-home network

Cable model

- Atenuation
- f -frequency, d - cable length K1 conductor loss, K2 dielectric loss

$$A_T = (K_1\sqrt{f} + K_2 f)d$$

- Channel capacity – constant parameters

$$C = B \cdot \log_2(1 + \frac{S}{N})$$

- Channel capacity – variable parameters

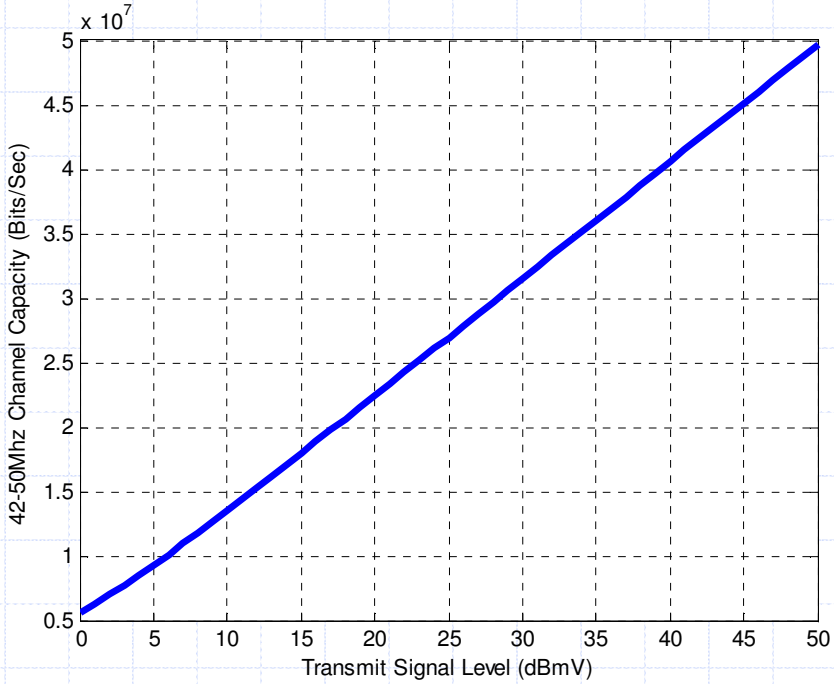
$$C = \int_{f_1}^{f_2} \log_2[1 + PSD\frac{S(f)}{N(f)}]df$$

Cable model

- **Components**
  - Splitters – most important components for in-home network
  - Taps – important for metropolitan networks
  - Complex components – will be included in future architectures (Home gateways)

Capacity evaluation

- Realized using a set of modules implemented in MATLAB



Eg. Channel capacity estimation in DOCSIS upload channel band

(42-50 MHz)

MoCA models are in early stage

Results

- DOCSIS - The maximum data rate (in PHY layer) can reach 50Mbps, close to the real values (60Mbps) included in technical standards. This is possible only in networks with a SNR over 25dB.
- DOCSIS is not a solution for in-home communication. DOCSIS is an asymmetric data link, useful in Internet access but less useful in high speed traffic, characteristic, for example, in multiple channel HDTV.

Results

- Future technologies (including MoCA) are using larger bandwidths (located in 1-2 GHz domain).
- MoCA - channel with 50MHz bandwidth
- Symmetrical communication is possible using time division multiplexing.
- Single channel can offer a capacity (in PHY) up to 250Mbps, usable in two-node communication.
- MoCA is offering a total capacity of up to 3Gbps in home networks.

Future work

New components in the system

- Components for MoCA networks and related models
- In this moment the advanced models for MoCA networks are missing

New features for the previous components

- Improved models in Matlab
- Development of alternative models using circuit simulation environments (Microcap) important for technical implementations
- Cross-validation of models in Matlab and Microcap

Conclusions

- The research - investigation of the main mathematical aspects of the models and set-up of methodology
- losses are generated by RF components
- some models recommended in references and used in this stage of research are outdated
- "old" and "new" technologies will co-exist in Connected Home architecture
- DOCSIS – access network for data services
- MoCA – in home multimedia connections, carrying mostly local traffic

Thank You!