Modeling and Simulation of Data Transmission in an ADSL Transceiver

Embedded Software Systems Literature Survey Briefing

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Overview

- ADSL Transceiver Architecture
- Problem Statement
- System Modeling
- Implementation
- Conclusion
Literature Overview

- Quadrature Amplitude Modulation (QAM)
- Inverse Fast Fourier Transform (IFFT)
- Fast Fourier Transform (FFT)
- Cyclic Prefix (CP) Extension: Intersymbol interference mitigation
- Equalization: channel effects suppression
  - Time-domain Equalizer (TEQ)
  - Frequency-domain Equalizer (FEQ)
ADSL Transceiver Architecture

A block diagram of an ADSL transceiver
Problem Statement

- Design a Synchronous Dataflow (SDF) model for data transmission in ADSL
  - Create an abstraction for Discrete Multi-tone based ADSL modems compliant with the standards
- Implement and simulate the data transmitter and receiver in LabVIEW
  - Implement physical layer functional blocks
  - Make it flexible for designers to modify and optimize the implementation to fit their own design
System Modeling

- SDF: best for DSP applications
- 1 token $\Leftrightarrow$ 1 sub-symbol (real/complex number)
- cp $\Leftrightarrow$ size of cyclic prefix extension
Channel Model

- Carrier serving area loops
- Eight different impulse responses
- Channel impulse response modeled as a finite impulse response filter
  - Computational Model: SDF node
  - Data type on arcs: Real numbers
    - Data Mirroring forces the IFFT to produce real output values
Implementation

- Implement the SDF model for data transmission subsystem using LabVIEW
  - Create a hierarchical design
    - Top-level virtual instrument (VI)
    - Sub-VI for every functional block called by the top-level VI
    - Start-up code: Ian Wong’s 802.16a simulation

- Channel Implementation: table lookup for eight different CSA loops.

- Equalization: use Embedded Signal Processing Lab Matlab TEQ Toolbox to generate the TEQ coefficients
LabVIEW Example

- Data Mirroring Block:
  - Array of size 2M

\[ X_i = \begin{cases} 
X_i & i = 1, \ldots, M - 1 \\
\text{Re}(X_M) & i = 0 \\
\text{Im}(X_M) & i = M \\
X_{N-i}^* & i = M + 1, \ldots, N - 1 
\end{cases} \]
Conclusion

● Deliverable:
  ● SDF model for an ADSL data transmission subsystem in LabVIEW
  ● Flexible framework for testing design
    ● Choice of channel model
    ● Choice of Equalization method

● Future work:
  ● Initialization phase
  ● Channel estimation
  ● Dynamic bit allocation tables
Questions and Answers