HDSL2 Modem Modeling and Simulation

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HDSL2 Overview

- High-bit-rate Digital Subscriber Line - 2nd Generation
  - Symmetric 1.544 Mbps
  - Applications
    - T1 replacement
    - Telecommuting
    - Internet access
  - Advantages Over T1
    - Much easier to deploy
      - Bridge taps OK
      - 12,000 feet range
      - Spectral compatibility
    - Single twisted pair

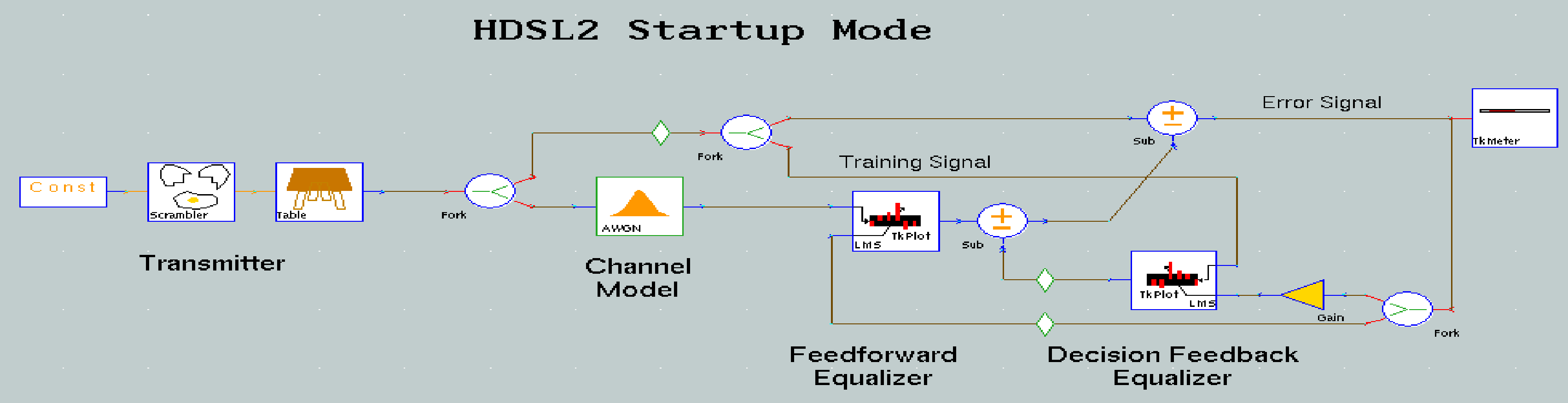
Project Overview

- Ptolemy Simulation
  - Trade-off analysis
    - Highly configurable
    - Extensible
  - SDF domain
- Reference Design
  - HDSL2
  - Other modems
- Ptolemy Contributions

Startup Mode

- Equalize channel
  - Reverse distortions
  - Adaptive filters in receiver
  - Training sequence
- Communicate parameters back to transmitter
  - Equalizer coefficients
  - Convolutional encoder polynomial

Startup Mode Simulation

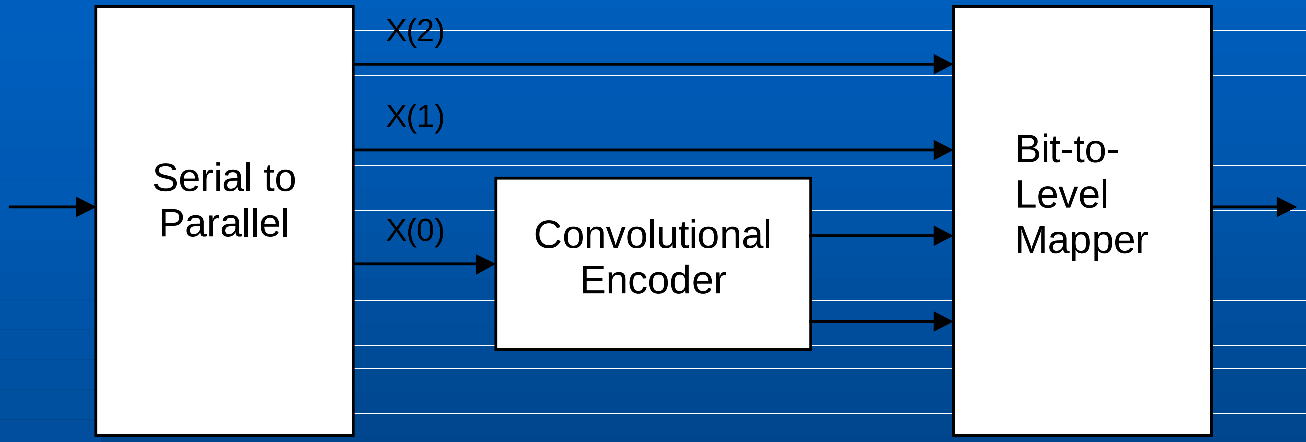


- **Configurable**
  - **Channel model**
  - **Adaptive equalizer**
- **Passes parameters to data mode through files**

Data Mode

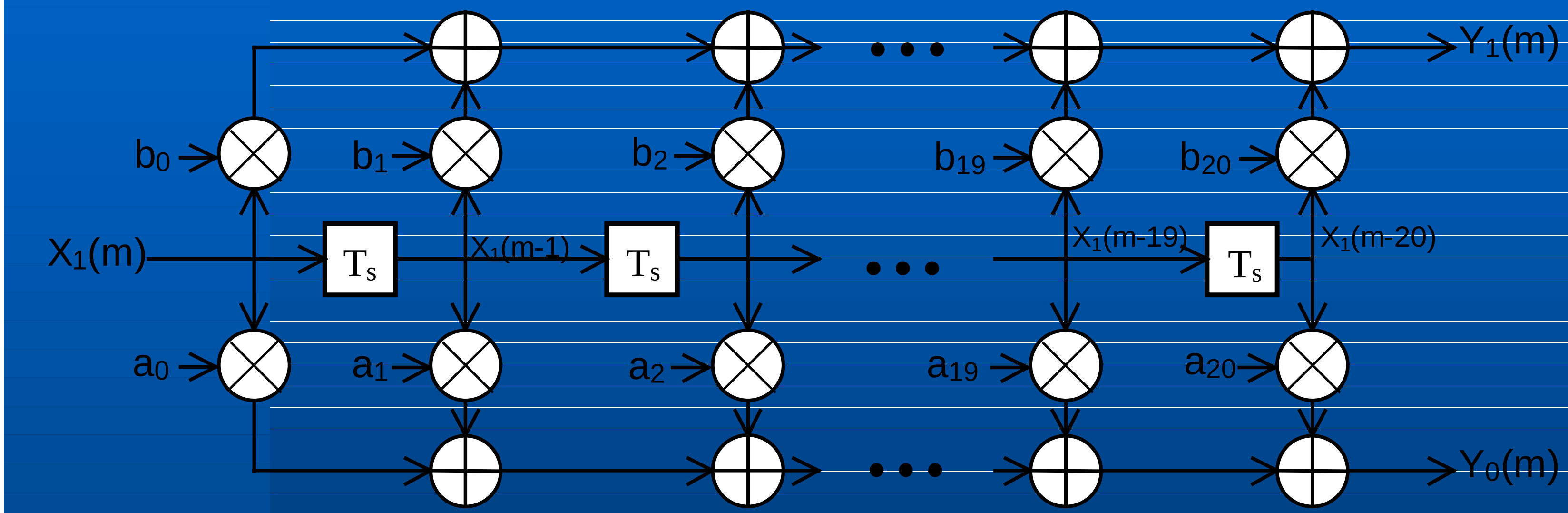
- Operating Mode
  - Sending and receiving data
- Additional Components
  - Transmitter
    - Trellis encoder
    - Tomlinson precoder
  - Receiver
    - Viterbi decoder

Trellis Encoder



- **Trellis Encoder**
  - **Adds redundancy**
  - **Output depends on state and input (512 states)**
  - **3 bits in - 16-PAM pulse out**

Programmable Encoder

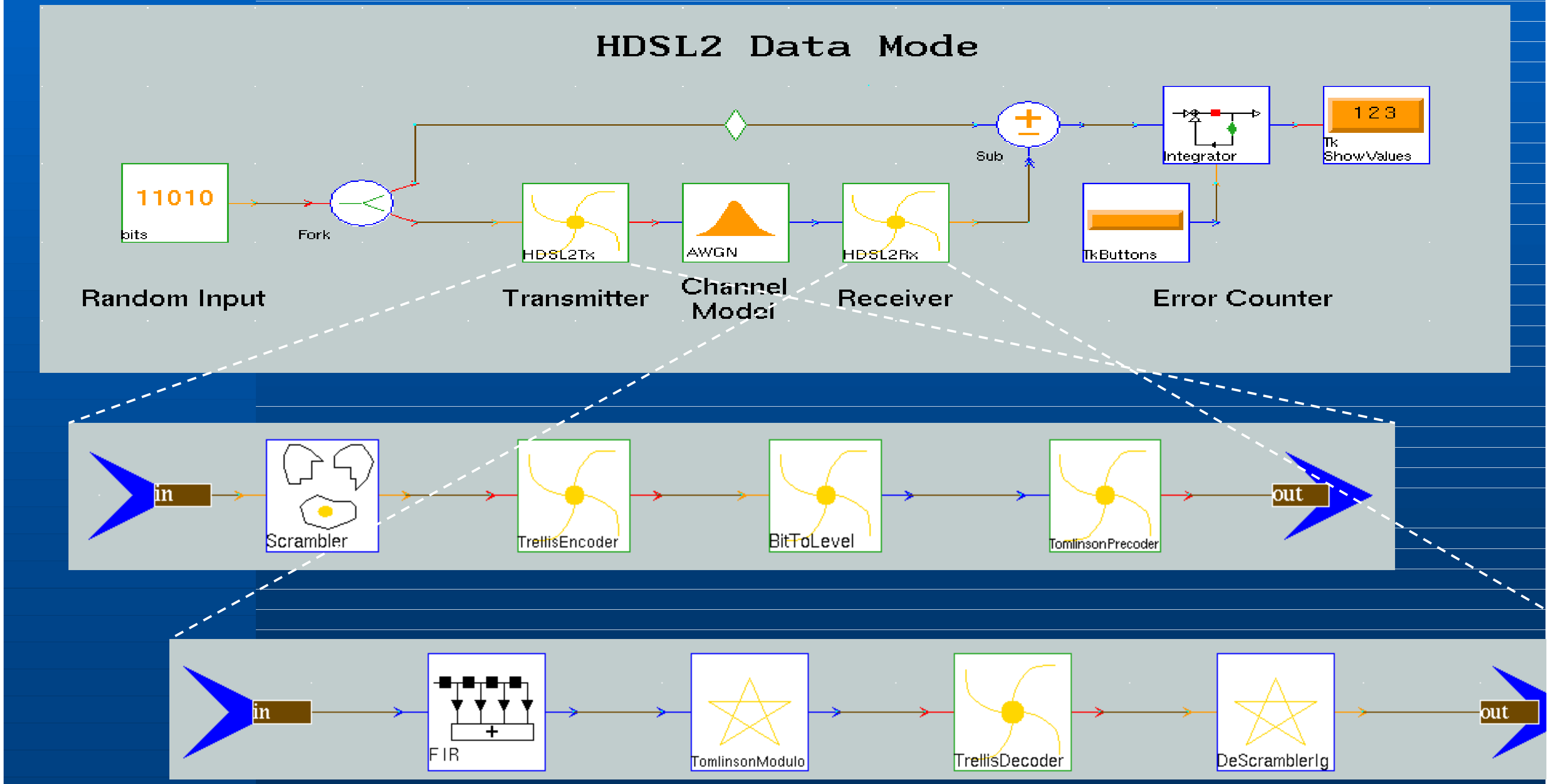


- **Convolutional Encoder**
  - **T_s = delay of one symbol time**
  - **⊕ = binary exclusive-OR**
  - **⊗ = binary AND**

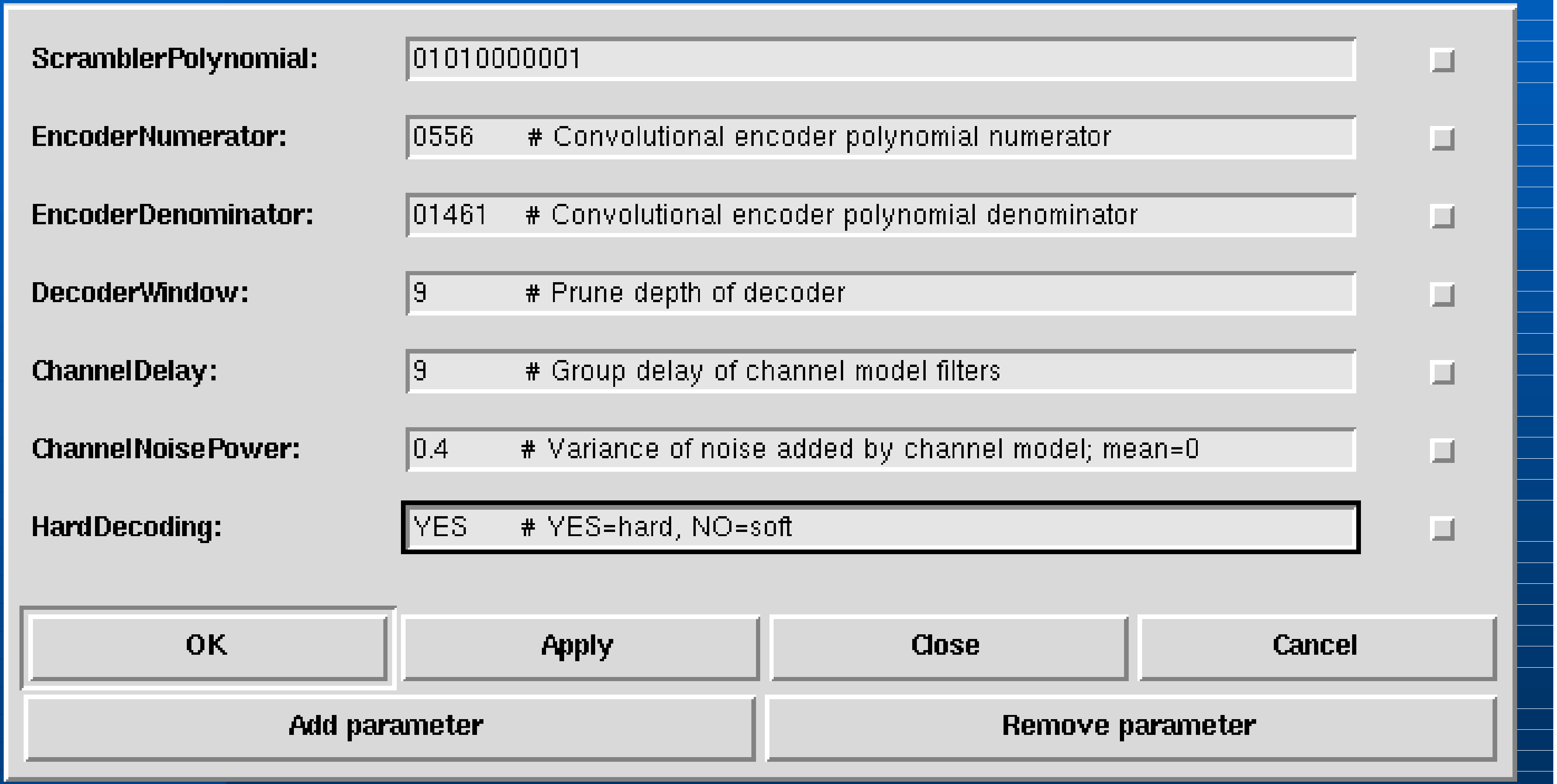
Trellis Decoder

- Viterbi Algorithm
  - Maximum likelihood sequence detection
    - Calculate difference between received codes and codes leading to next possible states
    - Choose minimal difference sequence
  - Window length
    - Sequence depth before decision
    - Trade-off: complexity,latency/gain

Data Mode Simulation



Simulation Parameters



ScramblerPolynomial: 01010000001 □

EncoderNumerator: 0556 # Convolutional encoder polynomial numerator □

EncoderDenominator: 01461 # Convolutional encoder polynomial denominator □

DecoderWindow: 9 # Prune depth of decoder □

ChannelDelay: 9 # Group delay of channel model filters □

ChannelNoisePower: 0.4 # Variance of noise added by channel model; mean=0 □

HardDecoding: YES # YES=hard, NO=soft □

Conclusion

- Contributions
  - Configurable/extensible simulation
  - Reference design
  - Ptolemy
    - Programmable Viterbi decoder
    - Tomlinson Precoder
- Limitations and Future Work
  - Startup-to-data mode sequence
    - Mixed FSM, BDF, and SDF
  - Timing recovery
    - Mixed BDF and SDF