MPRE Technology Overview

Mobile **P**hase **R**ecovering **E**qualizer

May, 2014

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V0.3

Agenda

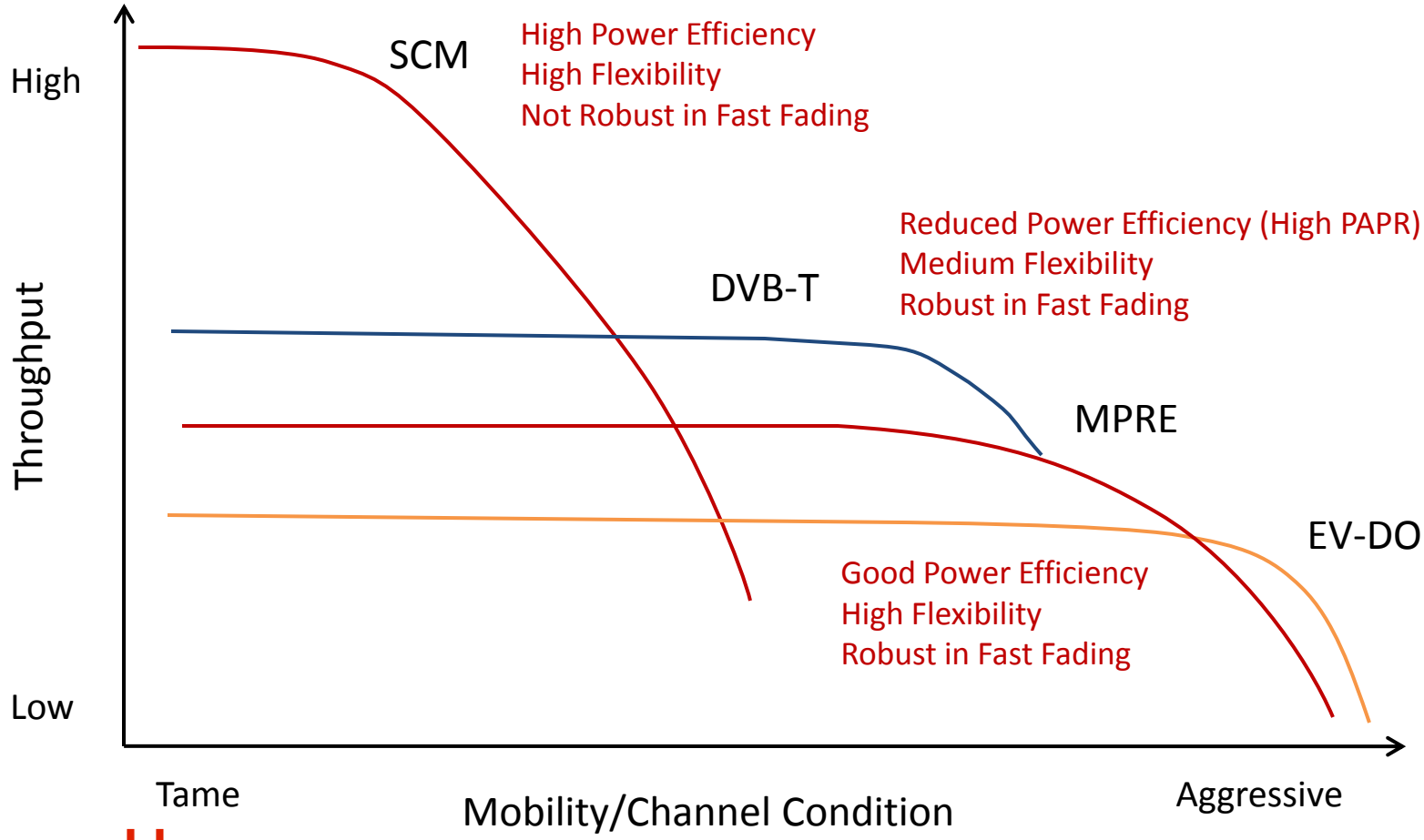
- **Introduction and Agenda**
- **Wireless Transport Hurdle**
- **MPRE Technology Solution**
- **Roadmap and Vision**
- **Summary**

Wireless Transport Hurdle

- Improved compression (e.g., H.264) reduces the required throughput for some video links below that supported by DVB-T
  - Wastes power and bandwidth for low-rate systems
- Narrow-band Single-Carrier Modulation (SCM) provides benefits via spectral power concentration and reduced PAPR
  - SCM susceptible to loss of carrier lock in fast fading
  - SCM desirable for range extension due to low PAPR
- Feed-forward phase processing with SCM provides robustness in fast fading
  - Ding!

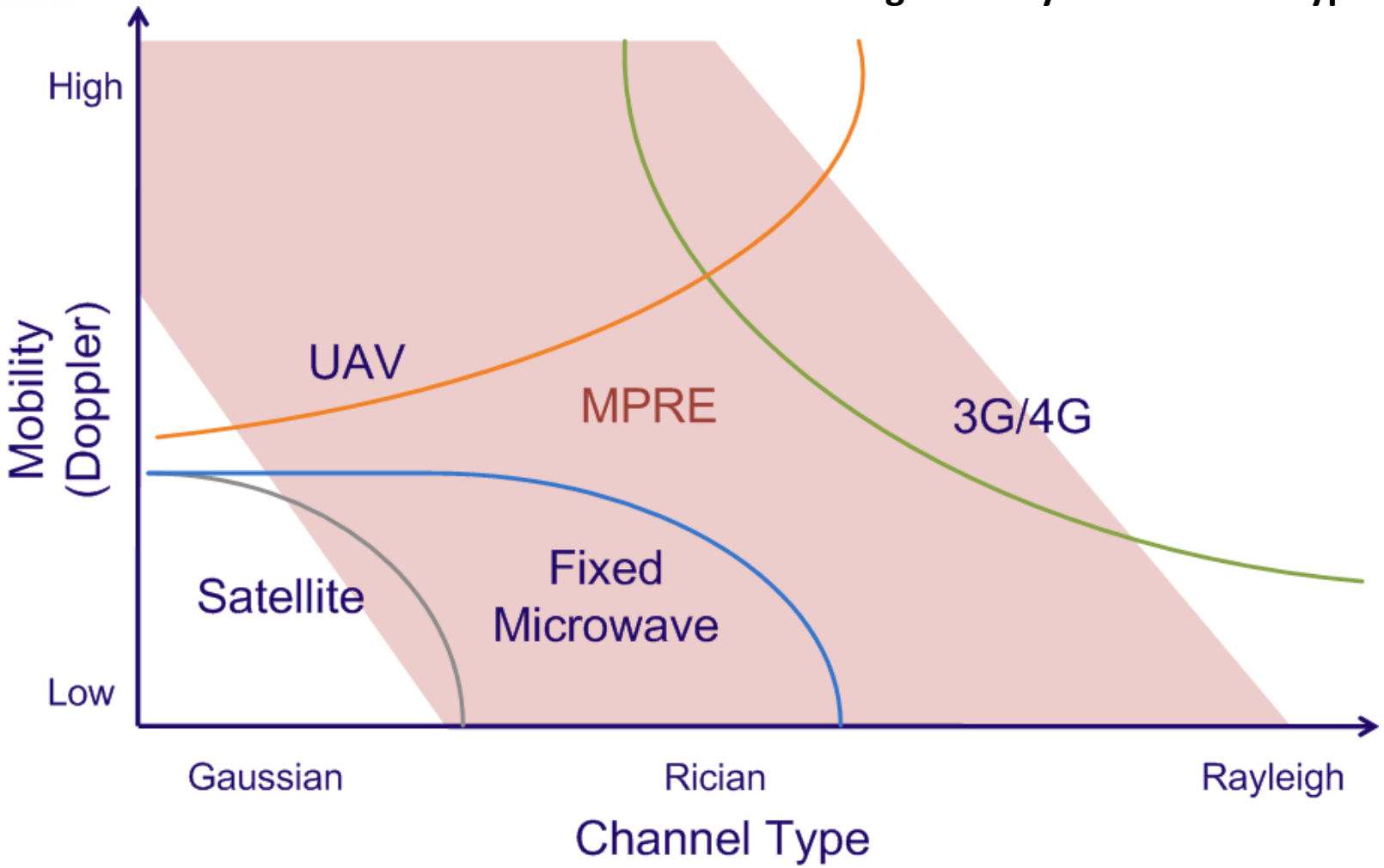
Wireless Transport Hurdle - 2

Generally as mobility increases, throughput decreases



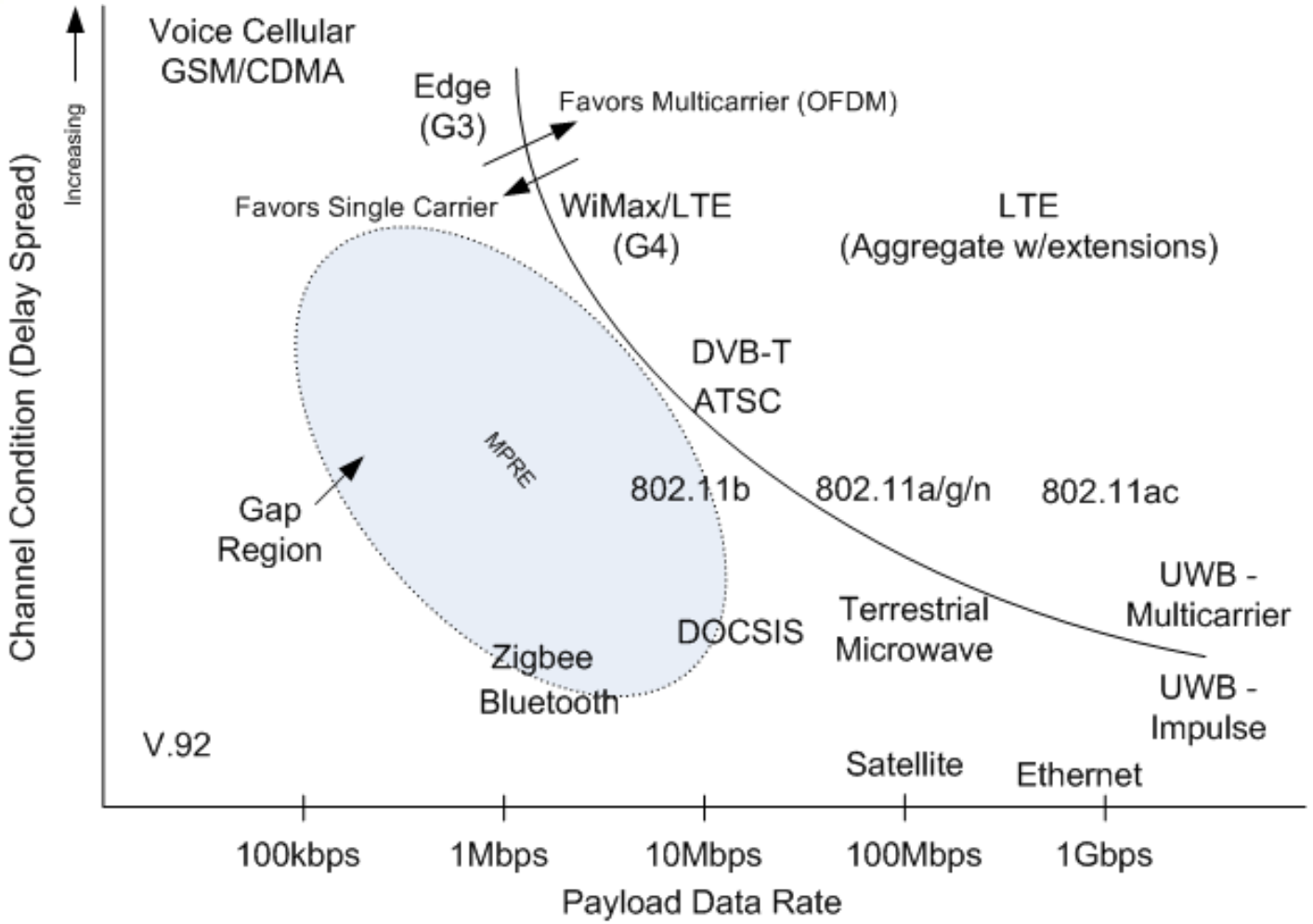
Wireless Transport Hurdle - 3

The MPRE fills a useful tradeoff area considering Mobility and Channel Type



Wireless Transport Hurdle - 4

The MPRE fills a useful application space not covered by other technologies.

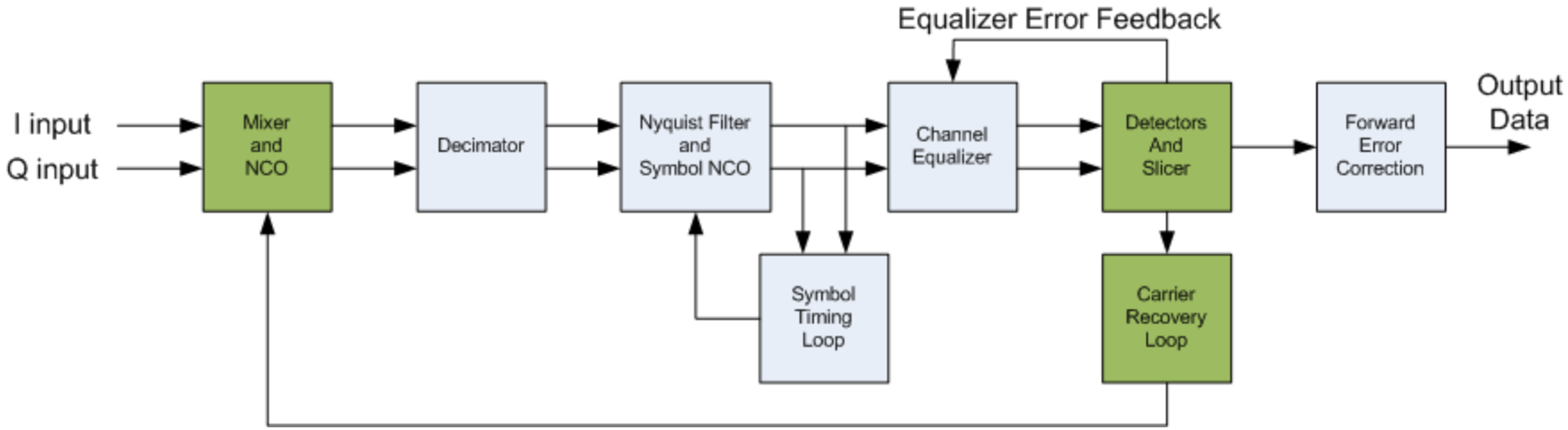


Mobile Phase Recovering Equalizer (MPRE)

- SCM Equalizer gets longer in time as symbol rate is decreased
  - Suitable in expected mobile multipath conditions for symbol rates below ~2 – 5 MHz
- Coherent SCM has difficulty maintaining carrier synchronization in multipath fading
  - MPRE Technology replaces traditional carrier loop with advanced signal processing
  - Unique processing system allows training of Equalizer even in heavy Doppler and fading

MPRE Technology - 2

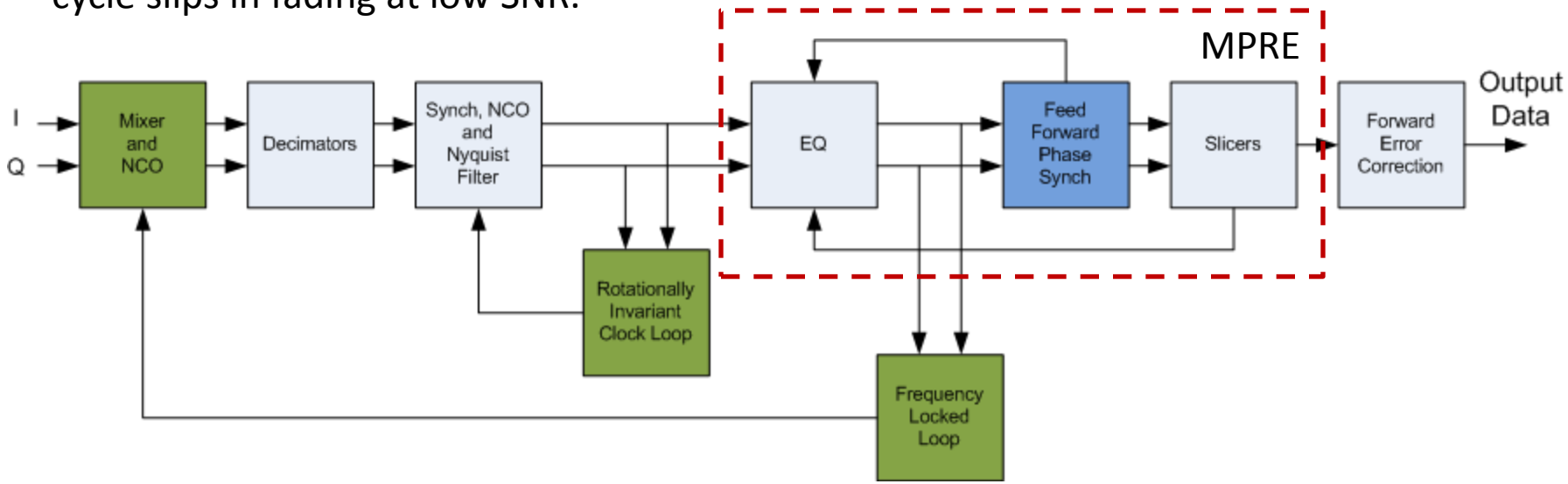
Traditional Carrier Synchronization with a PLL uses long-term phase averaging for maximum noise rejection. This approach assumes that perturbations to the loop are low-frequency and trackable within the loop bandwidth. In dynamic multipath fading the channel perturbations are frequently faster than the loop can track and carrier synchronization is lost.



A traditional coherent Single Carrier Demodulator uses the architecture shown, and loses carrier synchronization in fast Doppler fading.

MPRE Technology - 3

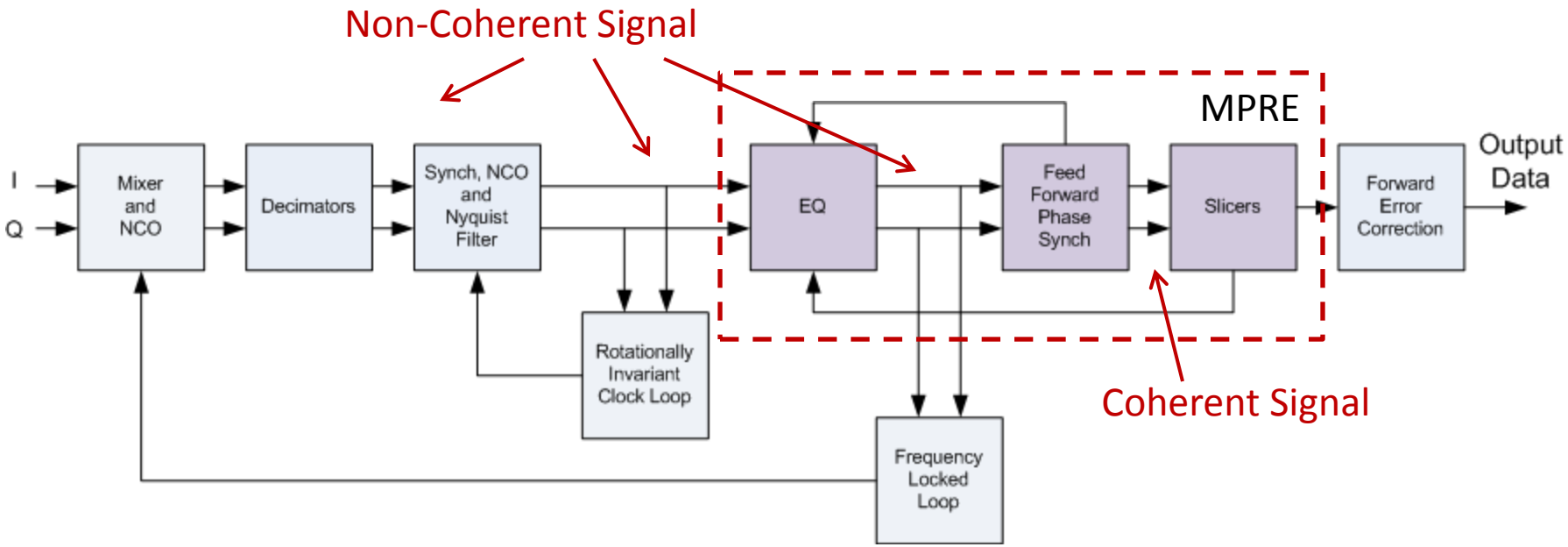
MPRE technology uses a short-term average of the signal phase history to provide an estimate of the carrier phase of the current symbol. This allows carrier synchronization to be maintained in dynamic multipath with a small cost in noise performance (<1dB). Differential encoding is used to provide immunity to inevitable cycle slips in fading at low SNR.



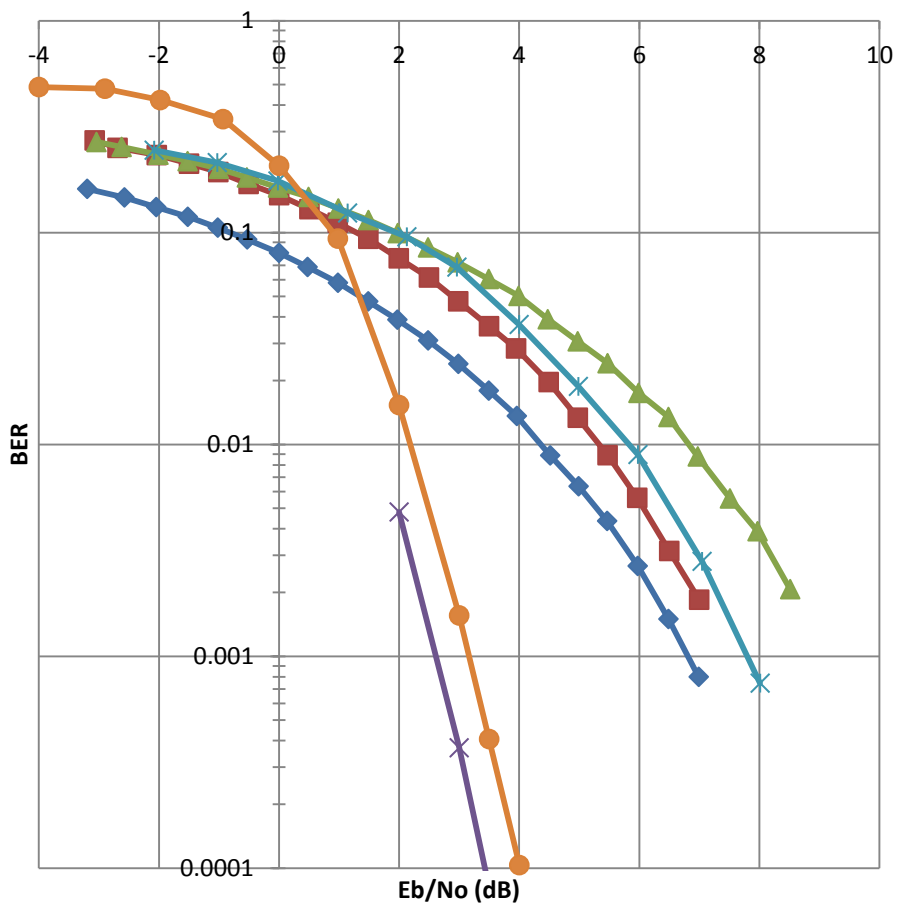
MPRE technology uses the architecture shown, and maintains carrier synchronization in fast Doppler fading. The carrier PLL is replaced with a feed-forward processing block and an FLL that provides fast signal acquisition.

MPRE Technology - 4

A key innovation in the MPRE is a proprietary technique that allows the equalizer to be trained coherently and properly equalize a non-Phase-Locked (aka, non-coherent) signal.



MPRE Technology - 5



The MPRE trades off a small decrease in performance in AWGN for a leap in mobile multipath channel reliability. The curves here show that the BER performance loss is less than 1 dB compared to a coherent demodulator. This enables substantial range extension compared to OFDM systems.

Roadmap and Vision

- The MPRE enables penetration of Single-Carrier systems into traditional OFDM applications
  - Medium-rate, narrow-band (e.g., < 5MHz) applications provide greatest opportunity
  - Power concentration and PAPR benefits
    - Improved range at same power
  - Flexible and Scalable in symbol rate
    - Allows adjustable channel bandwidth for improved spectral efficiency and reuse
  - Does *not* make OFDM obsolete

Roadmap and Vision - 2

- MPRE Technology is a new tool in the toolbox
  - Greater bandwidth and more flexibility than G3/G4/cellular (e.g., EV-DO) systems
  - Independent of Infrastructure (e.g., LTE)
  - May enable or enhance new applications
- MPRE Technology evolution – future improvements
  - 8PSK – higher spectral efficiency
  - Improved (longer) Equalizer
  - Advanced Algorithms
  - Integrated or Advanced FEC

Summary

The MPRE fills a technology gap

- Provides low-PAPR, medium-to-narrow-band solution for low-mobility Doppler fading
- Perfect for low-rate (e.g., H.264) video, telemetry, telemetry backhaul, etc.

The MPRE solution is unique

- May provide market advantage over competitors
- Patented