

Can an Added Value be offered to SDR Operators in Scenarios where Interoperability to Legacy radios is a Requirement?

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Motivation (1/2)

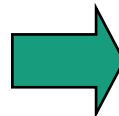
- Military tactical communications is taking its next evolution step
 - Key enabler: modern **Software Defined Radio** (SDR) Technology
- Before new Wideband Networking Waveforms (WNW) are available
 - Key challenge:

Concepts for Porting Legacy Waveforms to Software Defined Radios

Legacy Radio



© Thales Def. Deu



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Software Defined Radio

Motivation (2/2)

■ Different concepts

- one-to-one porting of signal processing → guaranteed interoperability
- introduce novel receiver signal processing → keep interoperability
- introduce novel transceiver signal processing
→ keep interoperability to legacy radios,
provide added value to SDR operators



■ Scenario

Today
Legacy only

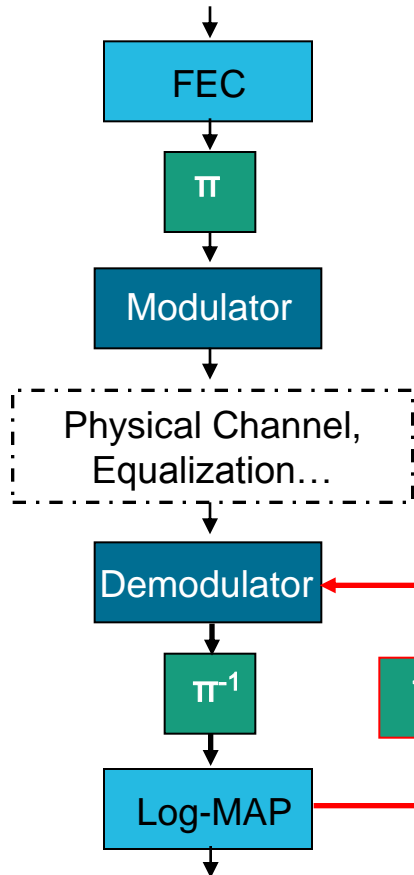


Tomorrow
Mixed Operation



Review First Approach

Bit Interleaved Coded Modulation with Iterative Decoding (BICM-ID)



■ Application of modern Signal Processing at Receiver

- „*Legacy Waveforms on Software Defined Radios: Benefits of Advanced Digital Signal Processing*“, in Proc. of NATO RTO IST-Panel Symposium (IST - 092 / RSY - 022), Breslau (Poland), Sept. 2010
- new: iterative feedback of **extrinsic information**

■ Results

- small gains if applied to standard configuration
r=½ Conv. Code G(171,133), 8-PSK Modulation w. Gray symbol labelling
- huge gains if symbol labelling is modified
→ loss of interoperability to legacy equipment

Proposed New Approach (1/3)

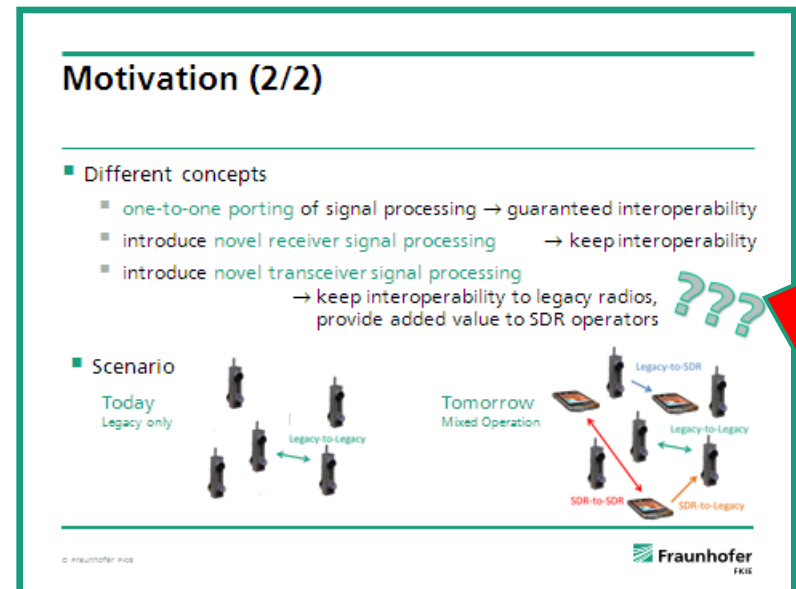
Introduce Hierarchical Modulation

- Can we change the signal processing at the transmitter while keeping interoperability to legacy equipment?

■ Proposed Solution

■ **Hierarchical Modulation** (aka Layered Modulation)

- *Base-Layer* ensures over-the-air interoperability
- *Enhancement-Layer* provides capacities for extended services

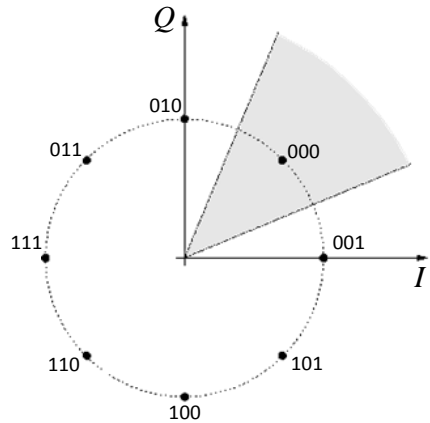


Proposed New Approach (2/3)

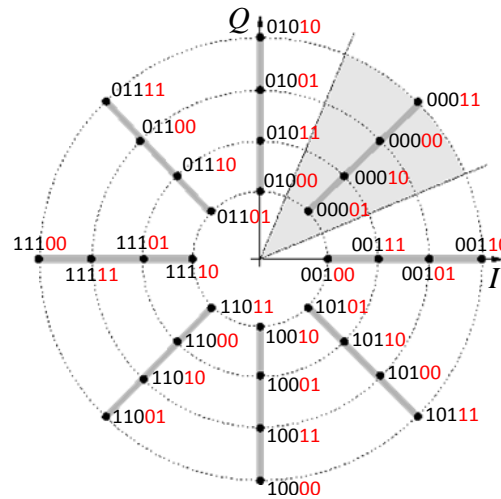
Star-shaped resp. Diamond-Shaped 32-QAM scheme

■ Example

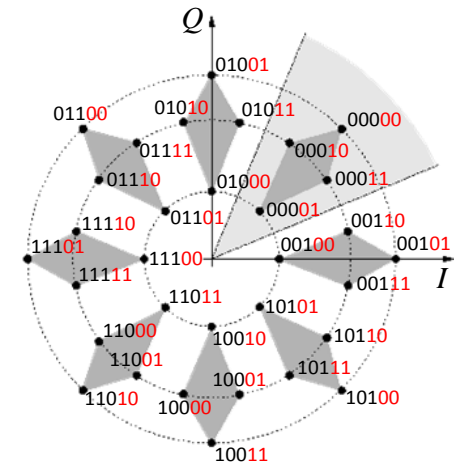
8-PSK Base-Layer



8-PSK Base-Layer +
4-ASK Enhancement-L.



8-PSK Base-Layer +
4-QAM Enhancement-L.

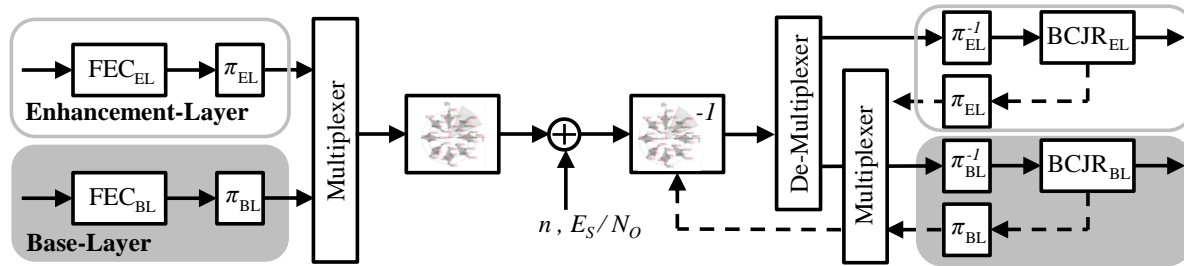


- design rules for Enhancement-Layers extensively discussed in the paper
- two additional bits can be transmitted on the enhancement-layer

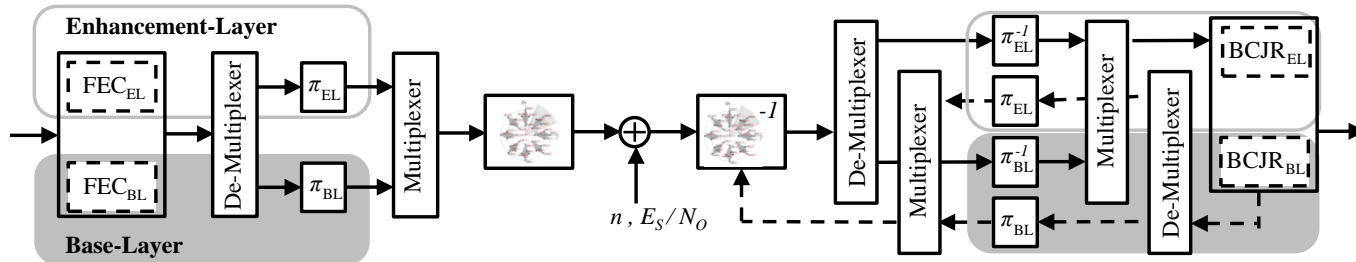
Proposed New Approach (3/3)

Introduce Hierarchical Modulation

- Extra Bit-Budget can e.g. be used in the following two ways
 - increase user's data throughput (focus of complementing paper at MCC'12)



- increase robustness (→ range) (focus of present presentation)

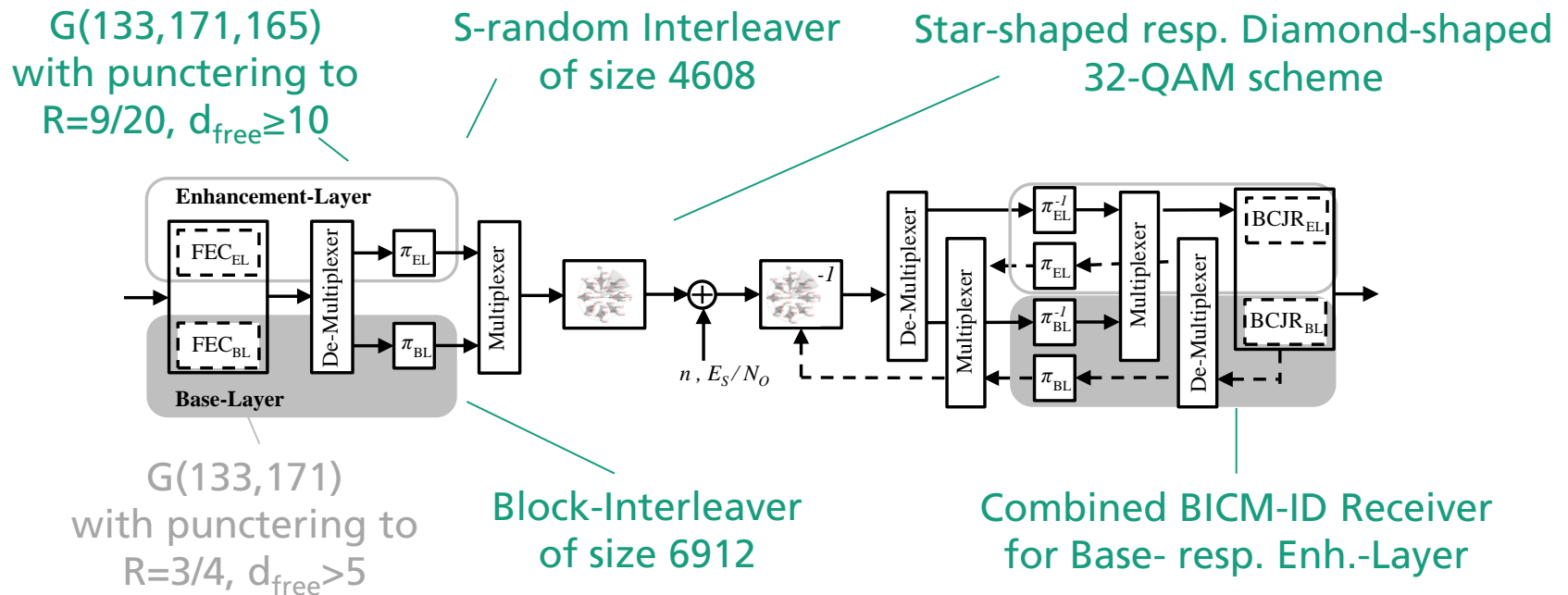


Simulation Results (1/6)

Simulation Example

■ Simulation Settings

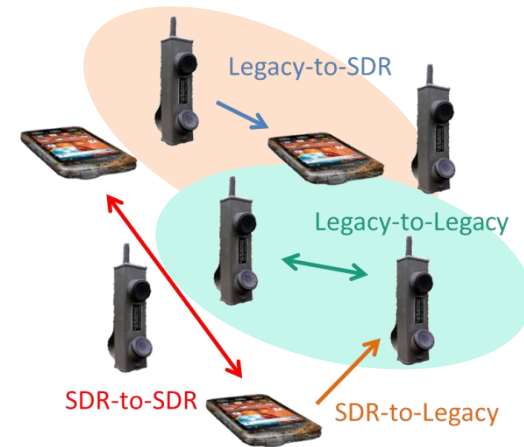
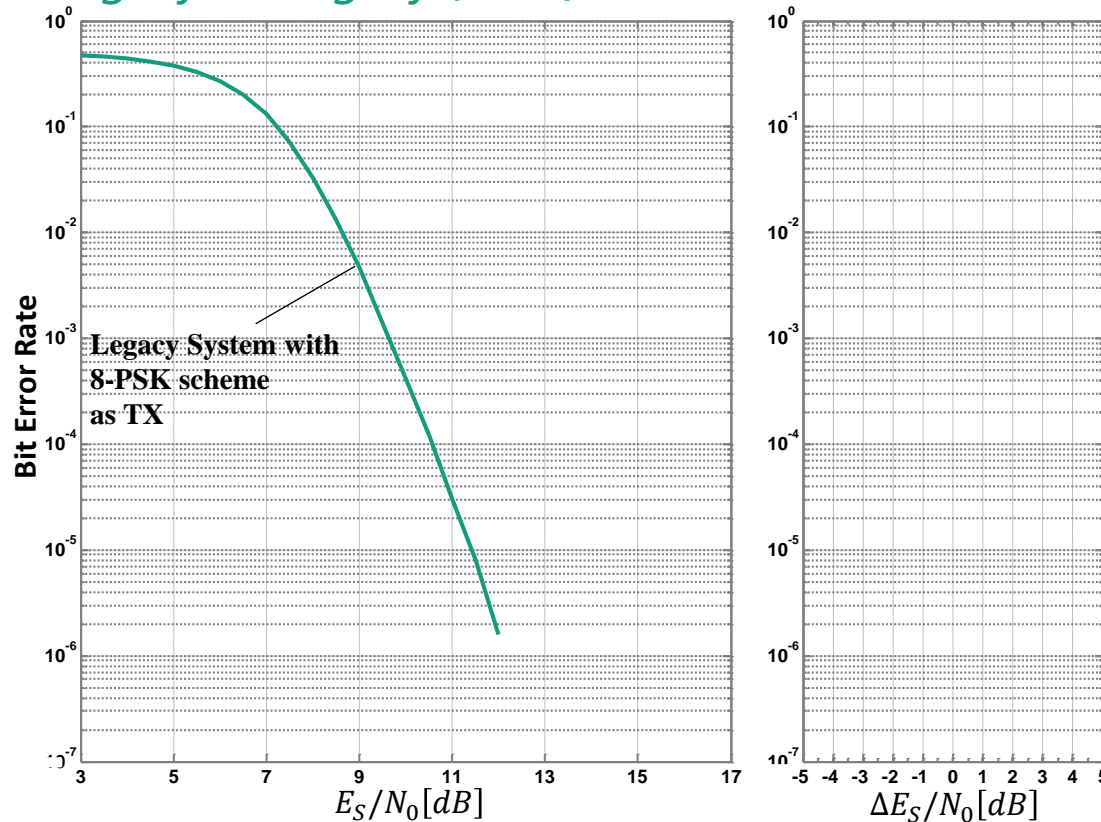
- Base-Layer resembles MIL-STD-188-110B Appendix C 4.8 kbps Mode



Simulation Results (2/6)

First Case: Legacy-to-Legacy (-SDR) Link

■ *Legacy-to-Legacy (-SDR) Link* serves as a reference

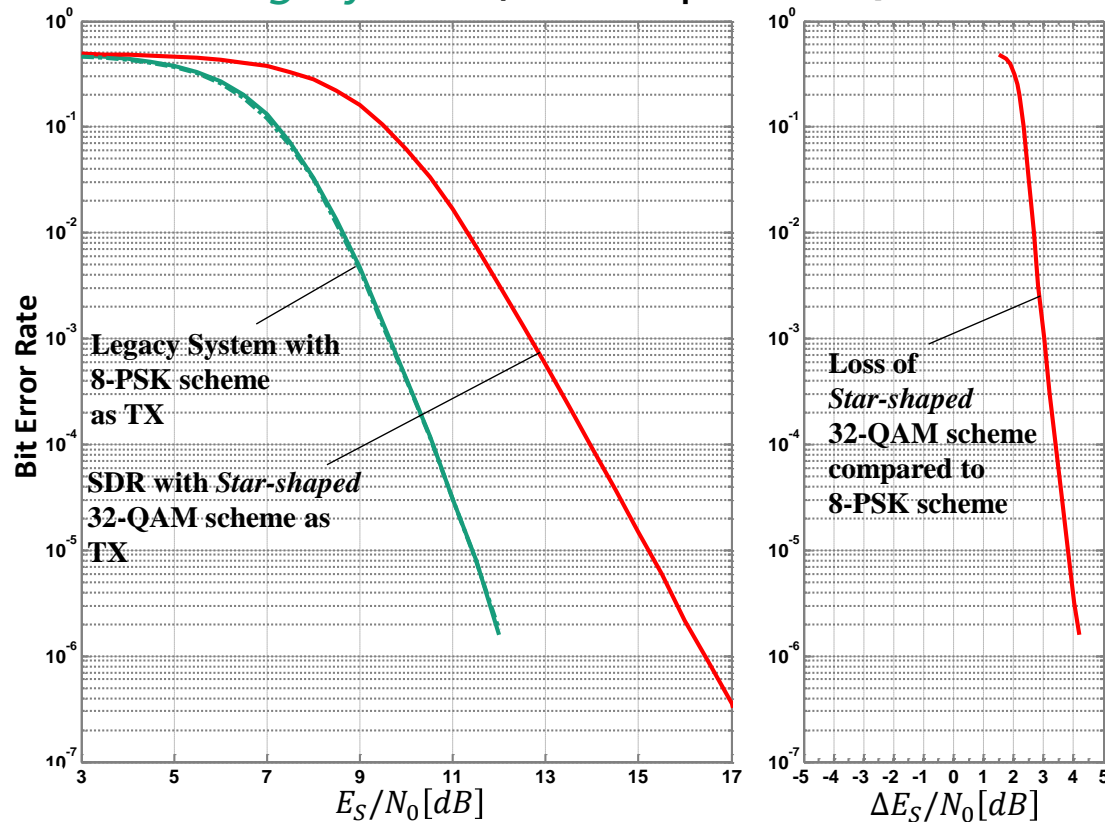


We assume that SDR decodes Base-Layer only if Legacy Radio acts as Transmitter.

Simulation Results (3/6)

Second Case: SDR-to-Legacy Link

■ *SDR-to-Legacy Link* (star-shaped 32-QAM scheme)

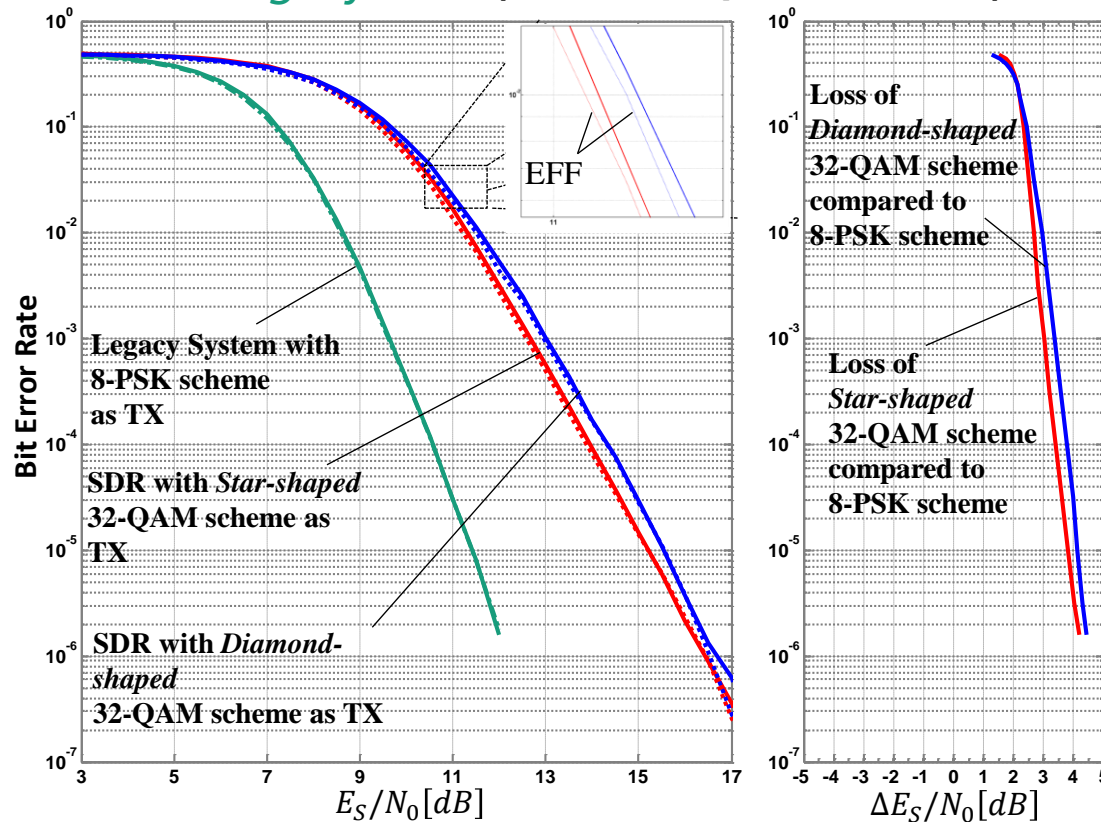


Enhancement-Layer
adds Noise to the Link

Simulation Results (4/6)

Second Case: SDR-to-Legacy Link

■ SDR-to-Legacy Link (both 32-QAM scheme)

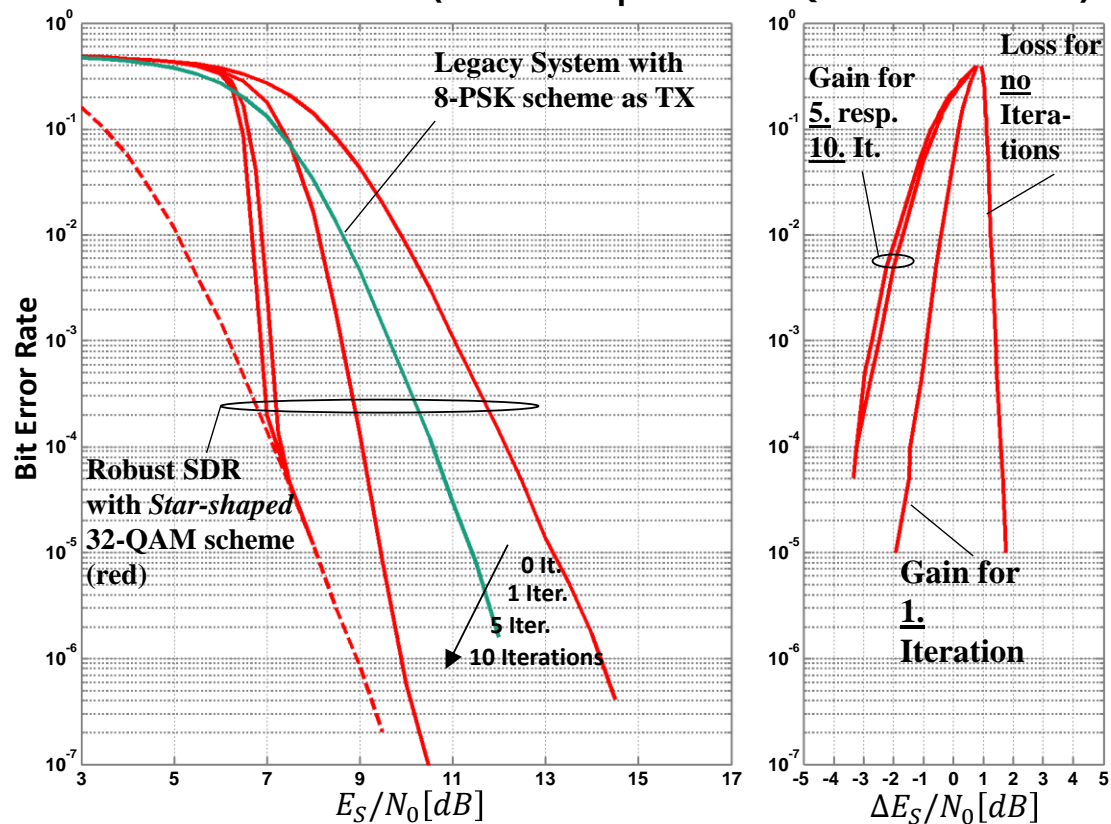


Enhancement-Layer adds Noise to the Link

Simulation Results (5/6)

Third Case: SDR-to-SDR Link

■ SDR-to-SDR Link (star-shaped 32-QAM scheme)

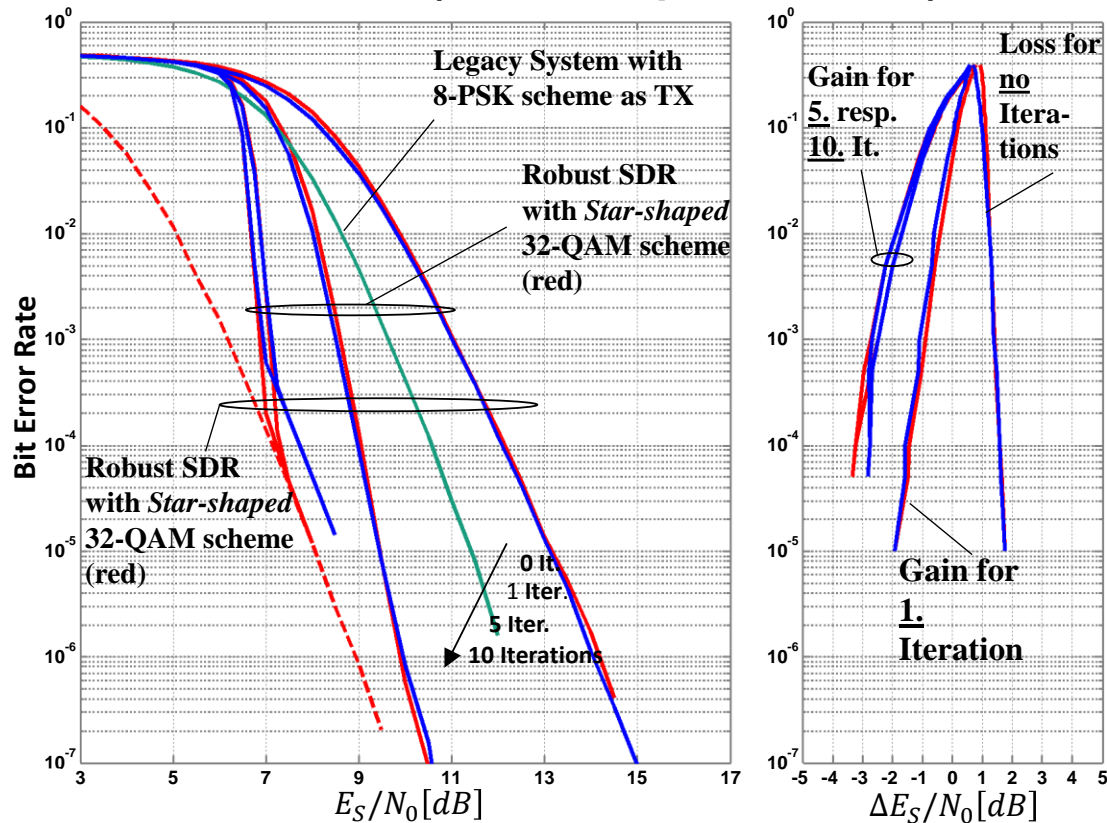


Considerable Gains
for more than
one Iteration

Simulation Results (6/6)

Third Case: SDR-to-SDR Link

■ SDR-to-SDR Link (both 32-QAM scheme)

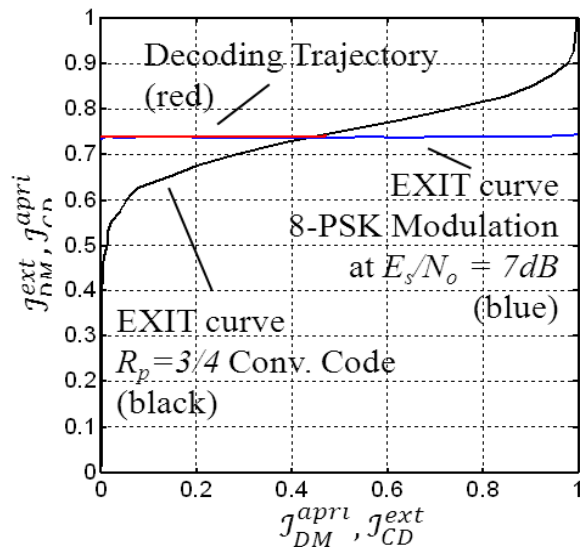


Considerable Gains
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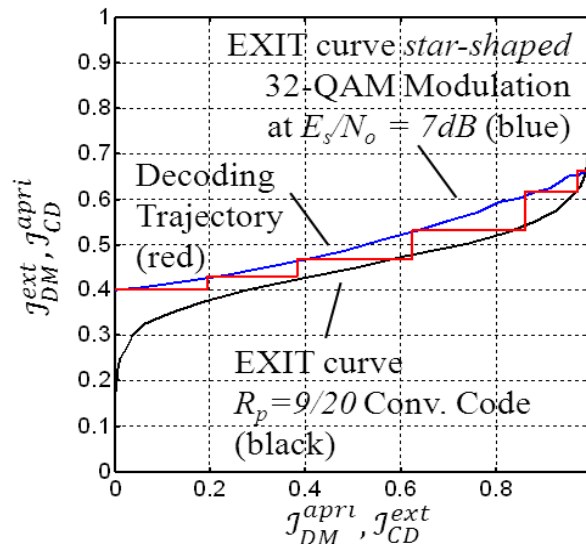
Convergence Analysis

Extrinsic Information Transfer (EXIT) Charts

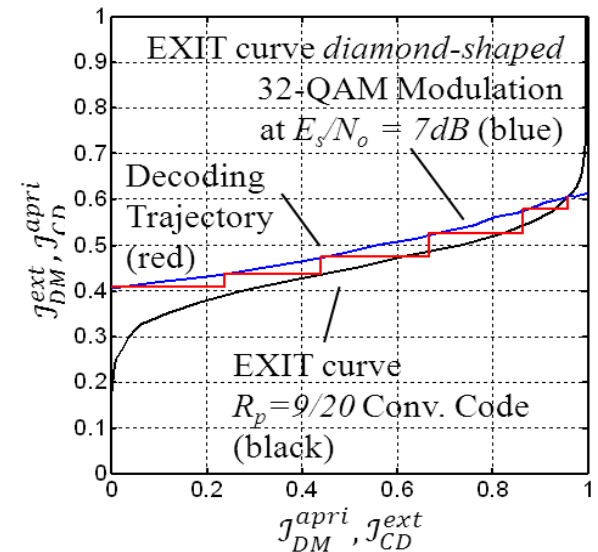
- **Decoding Trajectory** (Step Curve) illustrates information gains by iterations



8-PSK Base-Layer



8-PSK Base-Layer +
4-ASK Enhancement-L.

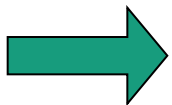


8-PSK Base-Layer +
4-QAM Enhancement-L.

Conclusion

Can Hierarchical Modulation offer an Added Value to SDR Operators?

- Legacy Radios and SDRs will operate in the same mission
- Our aim is to offer the operator at an SDR an Added Value
- **Hierarchical Modulation** (aka Layered Modulation)
 - *Base-Layer* ensures over-the-air interoperability
 - *Enhancement-Layer* provides capacities for extended services
 - increase user's data throughput (focus of complementing paper at MCC'12)
 - increase robustness (→ range) (focus of present presentation)



**Yes, the extra Bit Budget on the Enhancement-Layer
can be exploited to increase Error Robustness (→ Range).**

However, due to limitations in the design of Symbol Labels
no higher user Data Throughput can be realized.

Thanks for your Attention!

Questions or Comments?