Proposal of evaluating RBIR/ERBIR algorithms for LTE/LTE-A on the testbed in Heriot-Watt University

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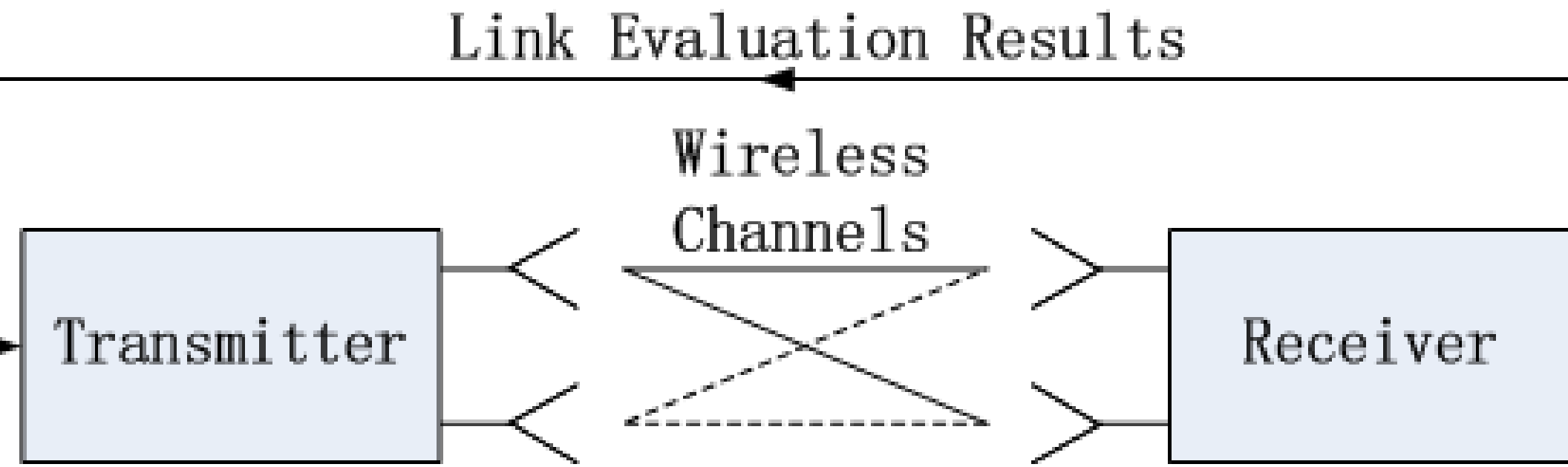
Outline

- Introduction
- Resource Block Information Rate (*RBIR*) and Extended RBIR (*ERBIR*) algorithms
- Demonstration of this technology on a testbed system
- Conclusions

Link Evaluation

- RBIR/ERBIR belongs to link evaluation technologies.
- Link evaluation aims to estimate the instant performance of transmissions for given channel status information (CSI), by a computational mod with reasonable complexity.
- The aim of link evaluation is to predict the Block Error Rate (BLER) of a transmission base on CS

Link Evaluation: Diagram



Link Evaluation: Application

Link Evaluation can be applied to:

- Link adaptation (LA)
  - Adaptive Modulation and Coding(AMC)
  - Layer mapping (indicate the rank of MIMO channels)
  - Precoding
- Hybrid automatic retransmission request (HARQ)
- Incremental retransmission (IR)

Link Evaluation: Common Method

- Effective Exponential Signal-to-noise-ratio Mapping (EESM)
- Mean Instantaneous Capacity (MIC)
- Mean Mutual Information per Bit (MMIB)
- *(Extended) Received Block Information Rate (RBIR/ERBIR)*

Motivation for our proposal

- EESM, MIC, MMIB are suitable for MMSE receivers, but not accurate for Maximum Likelihood (ML) detection of MIMO systems.
- EESM is the most common method for MMSE detection, whil in LTE/LTE-A, when two codewords use different Modulation Coding Schemes (MCS), EESM will be more inaccurate.
- Much work for the validation of RBIR/ERBIR has been done f 802.16m, and rare work has been done for LTE/LTE-A.

Motivation for our proposal

EESM algorithm: get the equivalent SNR for all subcarriers

$$\Gamma_{\mathrm{e}} = 10\lg\left\{-\beta\ln\left[\frac{1}{N_{\mathrm{c}}}\sum_{k=1}^{N_{\mathrm{c}}}\exp\left(-\frac{\gamma_k}{\beta}\right)\right]\right\}$$

Γ_e : equivalent SNR for all subcarriers

N_c: number of sub-carriers

γ_k : detected SNR on the k^{th} subcarrier

β : parameter needed to be acquired by simulation

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RBIR/ERBIR: Definition

Mutual Information Rate between Transmitted and Received Symbol of a block

$$\bar{I} = \frac{1}{\mathrm{lb}N} \underset{X,Y}{E}\left\{I(x;y)\right\} = \frac{1}{\mathrm{lb}N} \underset{X,Y}{E}\left\{\mathrm{lb}\left[NP(x|\mathrm{y}) \Big/ \sum_{i=1}^{N} P(q_i \mid y)\right]\right\}$$

x: transmitted symbols
y: received symbols
N: number of points in the constellation
q_i: i^{th} points in the constellation
I: mutual information between x and y
$\bar{I}$: average Information Rate in each resource block

RBIR/ERBIR: Mapping to BLER

Mapping of RBIR/ERBIR with BLER

$$P_B = \begin{cases} 1 & , P_B \geq 1 \\ \left[a_r erfc\left(\dfrac{\bar{I} \times r - a_q - b_r}{c_r} \right) \right]^{N_b/480} & , P_B < 1 \end{cases}$$

P_B: Block Error Rate

a_r , b_r , c_r : parameter related to turbo code rate (*acquired by simulation*)

a_q : parameter related to modulation (*acquired by simulation*)

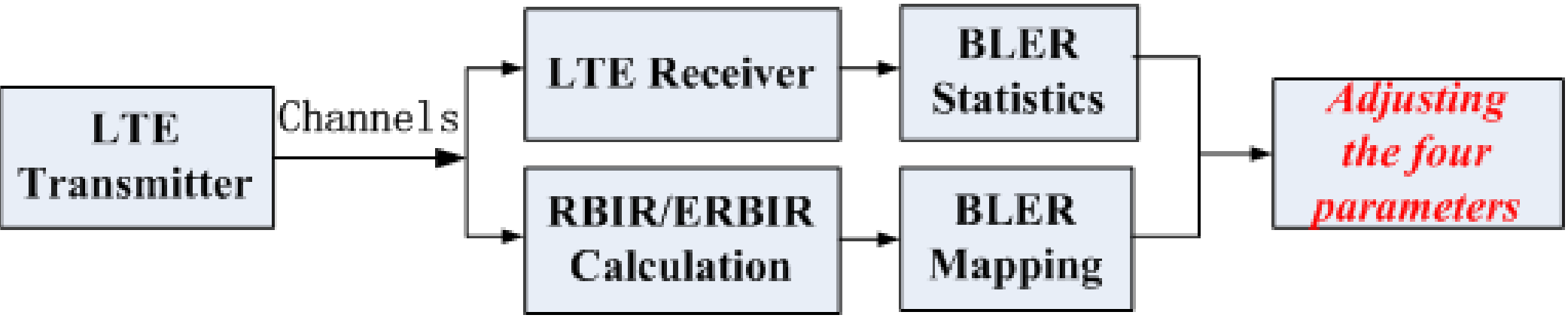
$\underline{r}$: turbo coding rate

$\bar{I}$: average Information Rate in each resource block

N_b : total number of symbols in a block

RBIR/ERBIR: Simulation Architectu

iagram for acquiring of four parameters for RBIR/ERBIR
LTE/LTE-A systems with pure computer simulation



Simulation Results in 802.16m

Transmission Mode	MSE				
	EESM	MIC	RBIR	MMIB	ERBIR
SO with MMSE	0.0369	0.1295	0. 0247	0. 0400	0. 0247
SO with ML	Not Supported	0.1296	Not Supported	0. 0469	0. 0241
EC with MMSE	0.0547	0.1348	0. 0604	0. 0622	0. 0604
EC with ML	Not Supported	0.3956	Not Supported	0. 1574	0.0956
EC with MMSE	0.0256	0.0851	0. 0206	0. 0312	0.0206
EC with ML	Not Supported	Not Supported	Not Supported	Not Supported	0.0791

Mean Square Error (MSE)
BLER between statistic a
mapping method is got
under 802.16m system wi

-- MIMO 2×2 Spatial Multiplex
-- Number of FFT points: 1024
-- Ideal Channel Estimation;
-- 70% ITU PedB 3kmph and 30% ITU VA 30kmph
-- Block size: 16 subcarriers × symbols;
-- MMSE/ML detection

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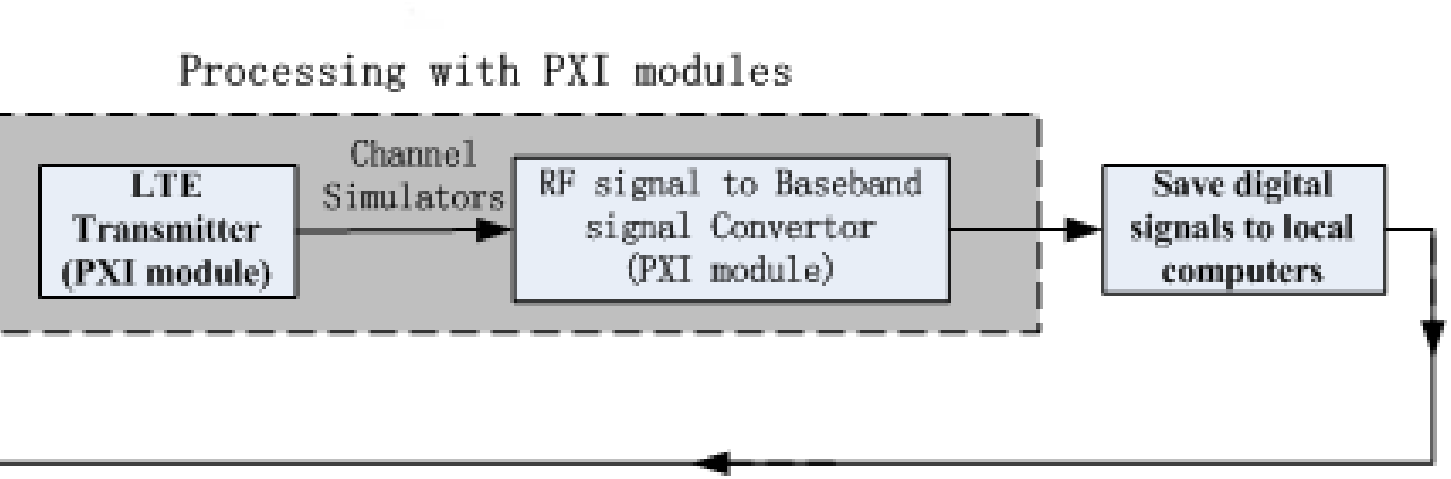
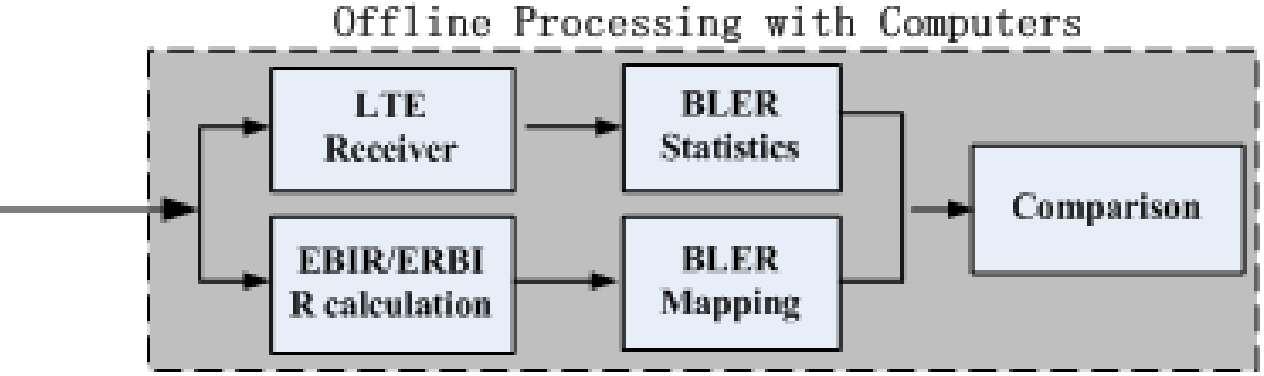
Architecture for testbed validation





Very similar with comp simulation, this architecture combines modules with compute

-- PXI modules transm LTE signals and conve RF signals from channe simulator into baseban signals

-- Computers deal with baseband signals and make comparison betw statistical results and results from RBIR map

Existing basis for the evaluation

HW university:

-- Lots of experienced experts

-- PXI modules, channel simulator and other equipments

WiCO:

-- LTE link & system level simulator (with standard C codes

-- Experience of combing computer simulation with PXI modules

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Conclusions

- Principle of RBIR/ERBIR algorithms
- Computer simulation architecture for acquiring four parameters for RBIR/ERBIR algorithm
- In 802.16m system, RBIR/ERBIR is more accurate and universal than all other link evaluation algorithms
- Testbed architecture for validation of RBIR/ERBIR for LTE/LTE-A system

Q & A