

R1-051427



**3GPP TSG-RAN1 Meeting #43**  
**Seoul, Korea, 7-11, November, 2005**

**Agenda Item: 8.5**  
**Source: Nortel**  
**Title: DL MIMO Modes for 4-Transmit Antenna**  
**Document for: Discussion**



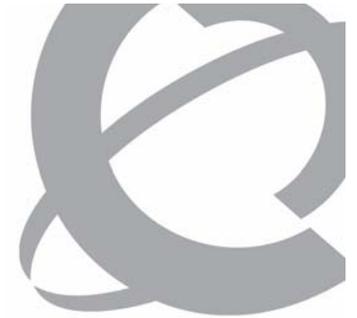
>THIS IS **THE WAY**

## DL MIMO Modes for 4-Transmit Antenna

Nortel

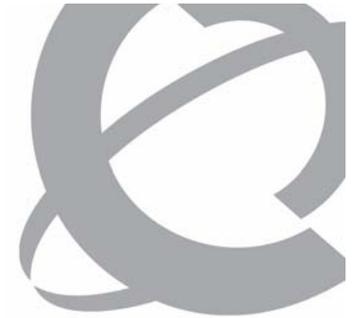
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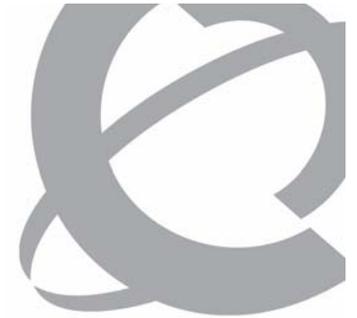
## Background and Introduction

- > For most of the Node-B deployments, 2-branch transmit is a realistic implementation at cell site
  - Due to several practical limitations such as cable, antenna size and zoning requirements
- > However, for some limited hot spot cases, 4-branch transmit MIMO is required to further increase the cell throughput
  - To further increase user bit rate or to enable SDMA to increase the capacity
- > The 4 branch transmit MIMO requires special design and optimization
  - For both open loop and closed loop
  - Also it is required to support diverse UE receive capabilities
- > We propose 3 MIMO modes for the 4-branch MIMO transmission



## 4-Transmit MIMO Code Rates

- > Due to the different UE MIMO receive capabilities, several MIMO modes for the 4-transmit case are defined
  - Rate-1 Code: single data stream mapped onto 4 transmit antennas
  - Rate-2 Code: two data streams mapped onto 4 transmit antennas
  - Rate-4 Code: four data streams mapped onto 4 transmit antennas
- > 3 MIMO modes are defined based the space time code rates
  - Rate-1 Code: full transmit diversity code, highest SNR gain
  - Rate-2 Code: mixed transmit diversity and spatial multiplexing code, with increased bit rate and SNR gain
  - Rate-4 Code: pure spatial multiplexing to achieve highest bit rate
- > For 4-transmit MIMO case, more MIMO modes are available to enhance the system performance
  - For 2-receive UE, Rate-1 and Rate-2 codes can be scheduled
  - For 4-receive UE, Rate-1,2 and 4 codes can be scheduled

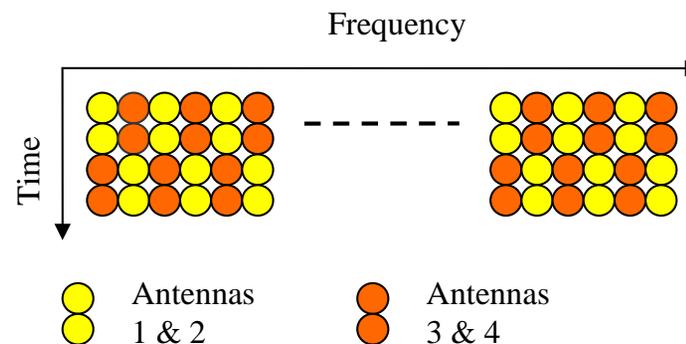


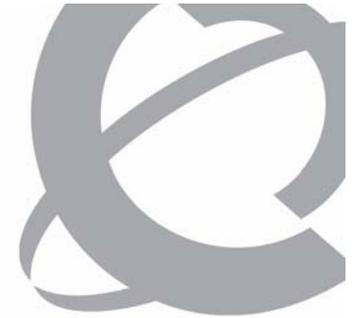
# Rate-1 Code

> This is a full diversity space time and frequency block code

	Time $t$ , sub-carrier $k$	Time $(t+T)$ , sub-carrier $k$	Time $t$ , sub-carrier $k+1$	Time $(t+T)$ , sub-carrier $k+1$
Antenna 1	$s_1$	$-s_2^*$	0	0
Antenna 2	$s_2$	$s_1^*$	0	0
Antenna 3	0	0	$s_3$	$-s_4^*$
Antenna 4	0	0	$s_4$	$s_3^*$

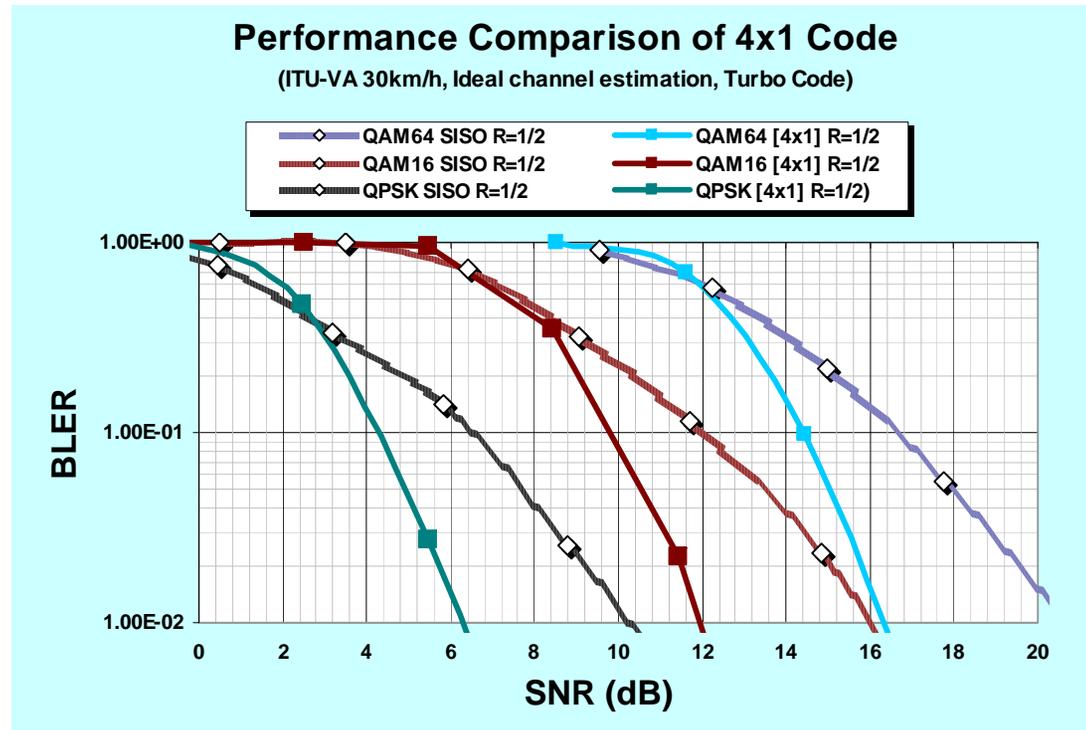
> With a compact space time and sub-carrier mapping structure



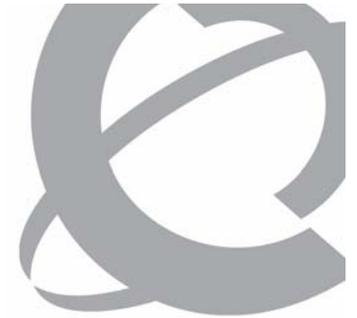


# Rate-1 Code Performance

- > This code enables single antenna reception and to achieve full diversity gain (4<sup>th</sup> order) by using the coded symbol interleaving
  - It also enable the simplest receiver: the classical Alamouti algorithm



- > The slot structure of the simulation is based on contribution R1-051159

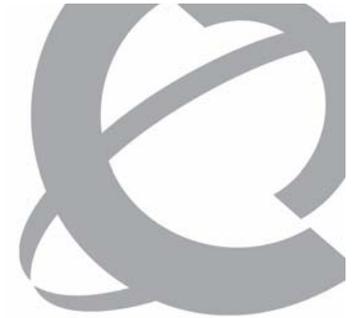


## Rate-2 Code

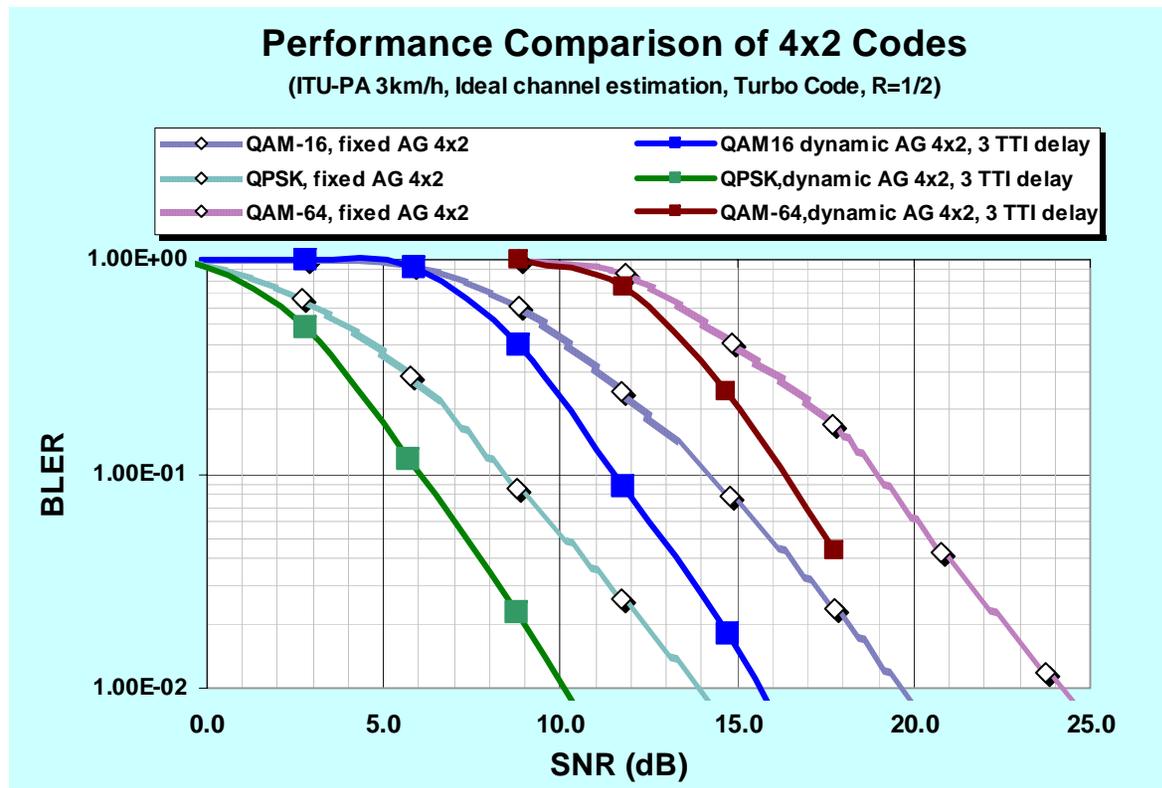
- > Rate-2 code has 3 equivalent sub-codes. This code enables dual receive antenna at UE and provide diversity gain
  - It also enables the MMSE receiver at UE

	Sub-Code #1		Sub-Code #2		Sub-Code #3	
	<i>Time t</i>	<i>Time t+T</i>	<i>Time t</i>	<i>Time t+T</i>	<i>Time t</i>	<i>Time t+T</i>
<i>Antenna 1</i>	$s_1$	$-s_2^*$	$s_1$	$-s_2^*$	$s_1$	$-s_2^*$
<i>Antenna 2</i>	$s_2$	$s_1^*$	$s_3$	$-s_4^*$	$s_3$	$-s_4^*$
<i>Antenna 3</i>	$s_3$	$-s_4^*$	$s_4$	$s_3^*$	$s_2$	$s_1^*$
<i>Antenna 4</i>	$s_4$	$s_3^*$	$s_2$	$s_1^*$	$s_4$	$s_3^*$

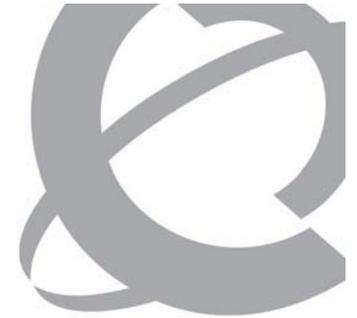
- > One of this unique advantages of this code is that it can operate in the closed-loop form by allowing UE select on the 3 sub-codes for each sub-band in the DL
  - Modest feedback (2-bit only) required by indicating to the Node-B one of a selected sub-code



# Rate-2 Code Performance



- > Dynamic selection of the best sub-code achieve SNR gain, the sub-code is in fact the base code with the permutation of antenna mapping, i.e. antenna grouping



## Rate-4 Code

> This is the 4 transmit spatial multiplexing code

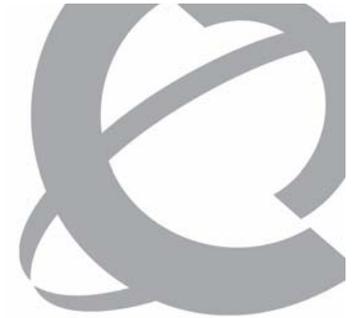
	<i>Time <math>t+T</math></i>	<i>Time <math>t</math></i>
<i>Antenna 1</i>	$s_5$	$s_1$
<i>Antenna 2</i>	$s_6$	$s_2$
<i>Antenna 3</i>	$s_7$	$s_3$
<i>Antenna 4</i>	$s_8$	$s_4$

> Achieve the maximum throughput, but requires higher UE SM decoder complexity



## The Adaptation of 3 MIMO Modes

- > For a 4-transmit cell the UE can select the 3 MIMO modes and perform dynamic adaptive modes selection
  - For 2-receive UE, it can select the Rate-1 code and 3 Rate-2 sub-codes
  - For 4-receive UE, it can select the Rate-1 code, three of Rate-2 sub-codes and Rate-4 code
- > The code rate selection can be based on the CQI and to determine the best modes based on UEs decision
- > The 3 Mode design is particularly useful for the FDD
  - Since the feedback required is very minimum



## Summary

- > We propose 3 MIMO modes for the 4 transmit MIMO configuration
  - Mode-1: achieve the full diversity gain
  - Mode-2: mixed diversity and spatial multiplexing gain
  - Mode-3: achieve the full spatial multiplexing gain
- > Node-B can base on the different UE receive capabilities and CQI to schedule different modes to achieve throughput and coverage gains.
- > The 3 MIMO modes also enable the co-existence of diverse UE receive capability in the same 4-transmit cell
  - Enable interoperability for UEs with 1,2 and 4 receive antennas