Project	**IEEE 802.20 Working Group on Mobile Broadband Wireless Access** <**http://grouper.ieee.org/groups/802/mbwa**>
Title	**TDD as an enabling technology for MBWA**
Date Submitted	**2003-01-10**
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Re:	MBWA Call for Contributions towards meeting #0, Fort Lauderdale, FL, January 13-17, 2003.
Abstract	This contribution presents the suitability of TDD as an enabling technology for MBWA and its specific design issues. It also discusses the interoperability issue and its importance.
Purpose	
Notice	
Release	
Patent Policy	

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TDD as an Enabling Technology for MBWA

802.20 meeting #0
January 13-17, 2003
Fort Lauderdale, FL.

Reza Arefi
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Outline

- **Why TDD?**
- Issues Specific to TDD
- Interoperability
- Conclusion

Why TDD?

- Spectrum
- Regulatory
- Support of IP traffic
- Performance
- Spectral Efficiency and Smart Antennas

Spectrum Issues

- **Spectrum is expensive**
- **In some cases spectrum is only available, or less costly, in unpaired bands suitable for TDD**
- **Even in the case of paired bands**
  - The band might be allocated as flexible-use (either TDD or FDD)
  - The duplex gap might be inadequate for FDD, thus making it more cost-effective for TDD due to RF design issues

Spectrum Issues

- **Mobility spectrum (~500-3500 MHz) is becoming increasingly crowded and fragmented worldwide**
  - Suitable spectrum is more likely to be allocated on an unpaired basis
  - Spectral neighbors/occupancy may vary on a market-to-market basis
    - unpaired provides operators with needed flexibility in spectrum usage and interference management
    - Example: MMDS, 700 MHz in the US
    - Only need to coordinate/find one clean block as opposed to two with an appropriate duplex spacing
  - Unpaired spectrum may also facilitate the establishment of national/regional footprint since it reduces the number of constraints in trying to find a block of spectrum that works in all relevant markets

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Regulatory Issues

- **In the US, FCC has taken initiative to reshape its policy towards spectrum allocation and usage towards greater spectral efficiency**
- **Markets around the world are expected to require greater spectral efficiency in the mobile bands over time**
- **There are pending (re)allocation procedures ongoing at the FCC at 800, 1900, and 2000 MHz, some may be available in time for MBWA**
  - Some unpaired spectrum (re)allocation is quite expected

Support of IP Traffic

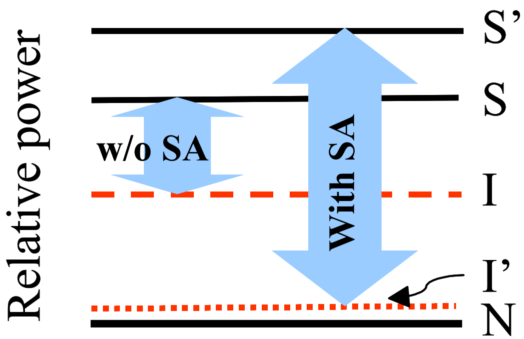
- **Internet traffic characterized as:**
  - Bursty
  - Usage patterns vary based on time, location, application
- **Thus it requires flexibility in supporting the degree of asymmetry between uplink and downlink**
  - It is important, therefore, that the air interface asymmetry is matched to the long-term average asymmetry of the traffic
- **TDD technology provides flexible approaches to supporting asymmetric uplink and downlink traffic**
- **TDD systems have achieved great success for data e.g., WLAN**

Performance Issues

- **802.20 PAR mandates:**
  - Sustained user bit rates significantly greater than existing mobile systems
  - Base station capacity significantly greater than existing mobile systems
  - Spectral efficiency significantly greater than existing mobile systems.
- **With increased spectral efficiency, per-user rates and overall throughput can both be increased.**
  - Typically, e.g., in going from 2G to 3G, per-user rates have been increased without much of an increase in overall throughput

Spectral Efficiency & Smart Antennas

- **Smart antennas provide better spectral efficiency (b/s/Hz/cell)**
  - by increasing ratio of desired-to-undesired energy throughout the network
  - substantially decreasing co- and adjacent channel interference in the network for a given in-band EIRP or “power on target”
  - The equivalent gain is in the 10’s of dB, far higher than the benefit provided by any other single technology
  - Higher user capacity through better S/(I+N)
  - Higher base station capacity through spatial channels and reuse of one or less than one



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Spectral Efficiency & Smart Antennas

- **They provide greater coverage**
- **Usage of smart antennas can be adapted to the morphology, for instance:**
  - In urban areas, focus on capacity
  - In rural areas, focus on coverage
- **They simplify/eliminate frequency planning in deployment**
- **They provide fading and multipath benefits**
- **They provide intrinsic redundancy**
- **Less UT power, longer battery life, cheaper terminals**

Spectral Efficiency & Smart Antennas

- **Smart antennas create lower co- and adjacent-channel interference**
  - Co-channel interference is reduced because the ratio of total radiated power to EIRP is much less
  - Adjacent channel interference is reduced for the same reason plus loss of coherency in the out-of-band pattern relative to the in-band pattern
- **Thus, Inter-system coexistence becomes easier and less costly**
- **More customers physically closer to the service boundary could be served**

Spectral Efficiency & Smart Antennas

- **While smart antennas enhance the performance of FDD systems, full capabilities of smart antennas are exploited under <u>TDD</u> where same carrier frequency is used for both uplink and downlink**
  - Channel Reciprocity
  - Downlink beamforming using uplink channel estimation
  - Enhanced spectral efficiency (b/s/Hz/cell) by combining TDD with Smart Antenna
- **Smart antenna solutions, which are critical for achieving wide area coverage and capacity, are cheaper, easier, more flexible and more robust in a TDD system**

$$Cells / km^2 = \frac{Demand\ (b/s/km^2)}{BW\ (Hz) \times Spectral\ Efficiency\ (b/s/Hz/cell)}$$

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Why TDD?

- Spectrum
- Regulatory
- Support of IP traffic
- Performance
- Spectral Efficiency and Smart Antennas

☞ **TDD is an attractive technology for MBWA**

Outline

- Why TDD?
- **Issues Specific to TDD**
- Interoperability
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Issues Specific to TDD

- RF design
- Propagation/channel model
- Implications on the air interface

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RF Design Issues

- **Transmit/Receive switch as opposed to duplexer**
- **Turn on/turn off settling times on the PAs**
  - Not a problem with smart antennas since low power PAs are used
- **Switching between uplink and downlink creates RF transients that must be controlled**
- **Coexistence may favor frame/timeslot synchronization between adjacent channel blocks**
- **Networks synchronization desirable**

Propagation & Channel Model Issues

- **For TDD and smart antennas, since UL and DL channels are reciprocal, forward and return links will be more correlated in both the spatial and temporal senses, reducing the implementation complexity of techniques such as time domain equalization**
  - e.g., through predistortion
- **Channel model**
  - Spatial: antenna-to-antenna correlation
  - Temporal: Delay spread profiles

Implications on the Air Interface

- **Frame structure**
  - Assuming smart antenna at the base station, best per-user performance requires uplink before downlink
  - Best network-wide capacity performance requires uplink and downlink to be allocated in paired way for all users
  - Time gaps (TX-to-RX, and RX-to-TX)
    - The MBWA emphasis being on information density (b/s/Hz/km^2) as opposed to super-cell range, the turn-around time can be small (80 microseconds corresponds to 12 km range)
    - Specifically, cell sizes suitable for cellular are quite easy to achieve when TDD is combined with smart antennas to enhance EIRP and sensitivity

Implications on the Air Interface

- **Resource management**
  - Open and closed loop power control
  - Link adaptation
  - Soft collision resolution
    - Significant benefit in MAC efficiency, resource management, and latency by allowing soft collision resolution

Implications on the Air Interface

- **Power control issues**
  - Fast fading is more correlated between uplink and downlink in TDD since TX and RX are on the same frequency
  - Thus, open loop power control is done with better accuracy in TDD due to correlated fast fading and symmetric path loss between uplink and downlink
  - Even with closed loop power control, reducing the amount of feedback (feedback adds overhead) or making possible a mode of operation in which no feedback is required, is beneficial
  - The use of AA reduces the need for super fast closed loop power control

Implications on the Air Interface

- **Broadcast channel and access control**
  - Natural disaffinity of AA solutions to broadcast channels, argues for relatively small amounts of heavily coded information to be sent over the broadcast channel
  - Polling channels, AA or otherwise
    - issue of latency
    - inherent limitations on scalability
    - cannibalization of traffic resources for control purposes

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- Why TDD?
- Issues Specific to TDD
- **Interoperability**
- Conclusion

Interoperability

- **Definition**
  - Interoperability: Ability of equipments from different manufacturers (or different systems) to communicate together on the same infrastructure (same system), or on another while roaming
  - What’s your definition?
- **Interoperability is a key factor in the success of any new technology**

MBWA & Interoperability

- **MBWA PAR calls for the support of TDD and FDD options**
  - Multiple options in standards are not attractive since they could create market confusion
  - TDD and FDD are not interoperable

<u>Issue</u>

To find the best way to provide for technical advantages promised by the MBWA PAR and, at the same time, reduce market confusion and help operators in the technology adoption process

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- **Conclusion**

Conclusion

- **TDD provides an attractive solution for MBWA by creating incentives related to:**
  - Licensing & operation
  - Performance
- **There are specific issues to be taken into consideration for the TDD option of MBWA that don't necessarily apply to the FDD option and vice versa**
- **802.20 needs to find ways of promoting interoperability and reducing market confusion without sacrificing the optimality of either of the options**

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