Dyaptive SYSTEMS

DMTS 8000 v2 Platform Scaling

Todd Sankey

September 18, 2003

1 Introduction

The DMTS 8000 version 2 platform will be as scalable as the version 1 platform, as well, it will provide hardware support to overcome some of the limitations of the version 1 platform. This document describes how the version 2 platform will scale to various numbers of sectors, sector-carriers, and VMTs. The document also describes how soft-handoff is achieved on the version 2 platform, as well as hard-handoff and other forms of frequency re-assignment, both from the customer perspective, and the DMTS developer perspective.

2 Terminology

Defining the exact terminology is an important step to clearly describing the capabilities of the platform. Some terms can have both a very precise definition and a somewhat more general definition. This dichotomy has lead to some confusion. Following is a list of terms with their definitions as used within this document. In some cases, the definition listed here is slightly different from the common, CDMA industry usage. These differences are due to the nature of the DMTS.

	Definition
Sector	A sector is basically an antenna port for a base station. It generates and receives a combined RF signal for multiple mobiles possibly operating at multiple frequencies.
Sector-Carrier	A sector-carrier is a single frequency channel (1.25 MHz or 5 MHz) from a single sector. It carries both forward (BTS to VMT) and reverse (VMT to BTS) traffic. It contains at most one pilot signal.
Transceiver Module	A transceiver converts the entire forward RF, or IF, signal from a single sector to a digitized signal sampled at a multiple of the base chip rate (1.2288 Mcps or 3.84 Mcps). This digitized signal carries all sector-carriers present in the original sector signal. The transceiver also converts a digital signal to RF or IF. The digital signal is the combined output of all VMTs transmitting to a given sector.
Sector-Carrier Port (SCP)	The hardware resource for receiving or transmitting on a single sector-carrier signal. The port receives the output from a transition module, and is programmable so that it can utilize one of the sector-carrier signals present, but at any given time it is only using one. All VMT's using the sector-carrier port are implicitly using the same sector-carrier signal.
Blade PE	A board that holds a collection of zero to eight sector-carrier ports, general-purpose processors for execution of VMT protocol stacks, and an attachment to a high-speed connection fabric for communicating with other blade PEs.
PHY Element	The collection of sector-carrier ports on a single blade PE.
Active Set	A VMT's active set is the set of sector-carrier signals that are currently being used to produce a single forward-link symbol data stream for the VMT. It is also the set of sector-carriers that are carrying VMT reverse-link traffic. If the size of the active set is greater than 1, then the VMT is in a soft-handoff state.
Candidate Set	A VMT's candidate set is the set of all sector-carrier signals **reported to the network** that it might potentially have in its active

	set, but are not currently in its active set. This will be constrained by the current state of the VMT and the test session.
Soft-Handoff	Soft (or softer) handoff is a the condition of a VMT in which it is: • Receiving forward link signals from multiple sectors on the same carrier, and the signals are identical at the symbol level with the exception of the power-control bits. • Sending reverse link signals to multiple sectors on the same carrier, and the signals are identical at the symbol level.
Hard-Handoff	Hard handoff is an event in which a VMT, under the direction of the network, instantaneously switches the contents of its active set during a call. The original active set may have one or more entries, and the target active set may have one or more entries. The original and target active sets are disjoint.
Frequency Re-assignment	Frequency re-assignment is the more general form of changing the active set (see hard-handoff). The VMT may or may not be in a call at the time, and the activity may or may not be network directed.
SCP Active Set	The SCP active set is the set of sector-carrier ports that a VMT is actively using to receive forward signals and transmit reverse signals. The SCP active set is always a subset of a single PHY element.
SCP Candidate Set	The SCP candidate set is the set of sector-carrier ports that a VMT might potentially use, but is not currently using, to receive and transmit signals. This set might be less than the set of all sector-carrier ports because the DMTS might be shared amongst multiple users, each with reservations on collection of ports.
PE-Handoff	A PE-handoff is the event in which a VMT instantaneously changes its SCP active set. The original and target sets are disjoint and the physical layer processing modules for the original and target are located on different blade processing elements. A PE-Handoff will always be the result of a change in the active set, but every active set change may not result in a PE-handoff. Also, the network has no knowledge of a PE-handoff.

3 DMTS System Scaling

A DMTS consists of one or more chassis. Each chassis consists of one to four transceiver modules, and one to nine blade processing elements (the CC does not really affect the scalability) to a maximum of twelve such cards in total per chassis. The DMTS capability can be increased in three dimensions:

- The DMTS can support additional sectors by adding transceiver modules (this may also require adding sector-carrier ports, but may not).
- The DMTS can support additional sector-carriers by adding blade PEs with sector-carrier ports. This also adds VMTs.
- The DMTS can support additional VMTs by adding blade PEs (with or without sector-carrier ports).

The three are scalable independently, subject only to the constraint of what a chassis can hold.

Within a chassis, the sector-carrier ports have access to all of the signals from all transceiver modules. Signals from transceiver modules never span chassis. Signals from VMTs to sector-carrier ports can span chassis, but a VMT only ever uses a single PHY element at any instant.

4 Mobility Simulation

Mobility and network load management within a CDMA wireless network result in changes to the active set of a mobile. The changes can be the result of network direction, or the mobile can manage them. A change to the active set may happen while in a call, during network access, or while the mobile is idle. A change may result in an active set with no members in common with the original set (disjoint), or the original set may overlap with the final set. Soft, softer, hard and idle handoffs are all types of changes to the active set.

Not all permutations are permitted in a CDMA wireless network. For example, the network always manages active set changes during a call; the mobile provides measurement data, but the network validates and authorizes the changes. The mobile usually manages changes to the active set while in idle with no network involvement.

A fully capable simulation would impose no restrictions on a VMTs active set or the types of changes that can be made to it. The signalling defined in the standard allows the network to direct the mobile to adopt an arbitrary active set. Setting this capability as a system requirement, however, is very demanding because it requires that power control and soft-symbol data be moved extensively between blade PEs with very low latency.

Fortunately, it is reasonable to assume that a mobile is only going to be directed to adopt an active set that is appropriate for its (estimated) location (i.e. the network will not direct the mobile to use a signal from a sector that is probably very weak at the mobile's location). Also, the mobile has some influence over the types of changes the network can impose by what the mobile reports to the network.

Assuming the DMTS will be used in a manner that models a real network layout, we can reduce the demands a fully capable simulation would impose. A good candidate for such a simplification is the assumption that sector signals processed by a single blade PE are, by definition, geographically close to each other. Sector signals processed by different blade PEs are geographically separated[1]. Effectively, the sector-carrier ports tuned to the same carrier frequency on a blade PE define a geographic area of network coverage[2].

With this simplification we can constrain the active set of a VMT to be the same as the SCP active set of the VMT. This removes the need to transmit soft-symbol and power control information between blade PEs.

As long as the size of its active set is 1, a VMT can move anywhere within the system by performing a PE-Handoff. When the size of its active set is greater than 1 (i.e. it is in soft handoff), a VMT is constrained to virtually move in a continuous manner only in the geographic region defined by the sector-carrier ports on its serving blade PE. This constraint can be lessened provided a single blade PE can satisfy the proposed active

[1] This assumption requires that the user configure the sector-carrier ports to be used in a manner that is consistent with this assumption.
[2] This allows the possibility of something akin to quantum tunneling. If some ports on a blade are on different frequencies, a VMT is capable of 'instantaneously moving' if the ports are also on different sectors. This jump, however, would be directed by the network, so would not be seen in practice.

set. This amounts to configuring the system such that blade PEs provide overlapping coverage of sector-carriers. Then, an active set change during soft handoff may also include a PE-handoff.

For purposes of illustration, Figure 1 shows a 7 base station / 21 sector network with the sectors labelled A through U. Assume that these are single carrier base stations and all are on the same carrier.

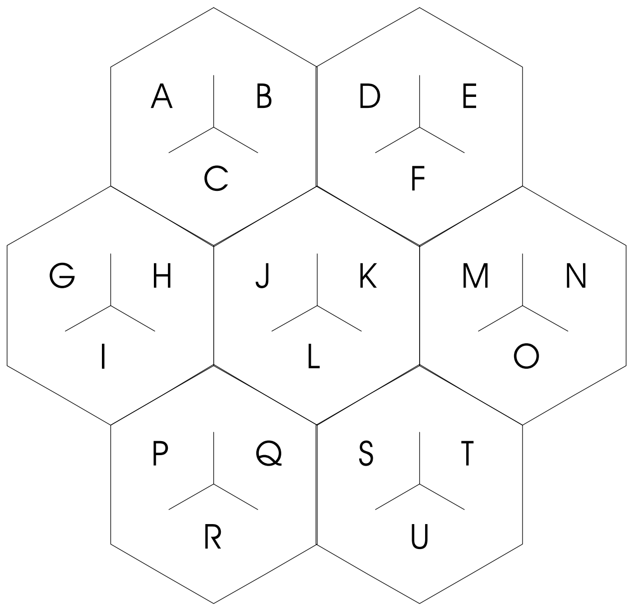

Figure 1 - Network Layout

Assume that the DMTS is configured so that the blade PEs cover the regions shown in Figure 2.

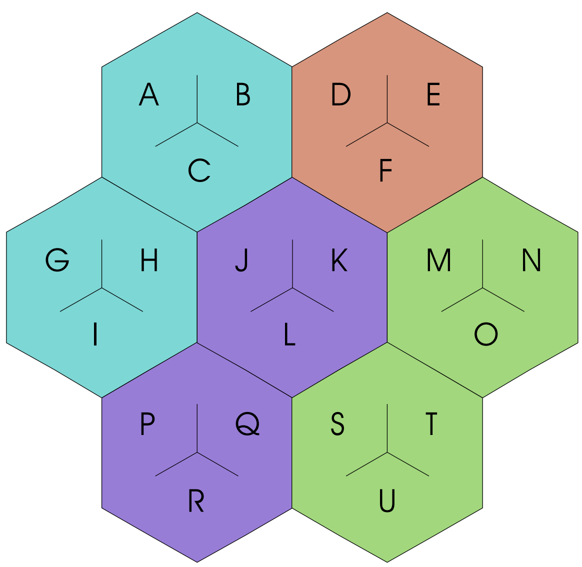

Figure 2 – PE Blade Coverage With No Overlap

In this case, there is no overlap between blade PEs. Any type of active set change is possible provided the active set size for the VMT before or after the change is 1. In soft-handoff, a VMT is constrained to one of the 4 coverage zones shown in the figure. It can cross coverage zones only as the result of a hard-handoff or by leaving soft-handoff. The VMT would insure this by never reporting to the network that it gets adequate signal strength from any sector-carrier outside of its current coverage zone. Then the network will never direct it to add an invalid sector-carrier to its active set.

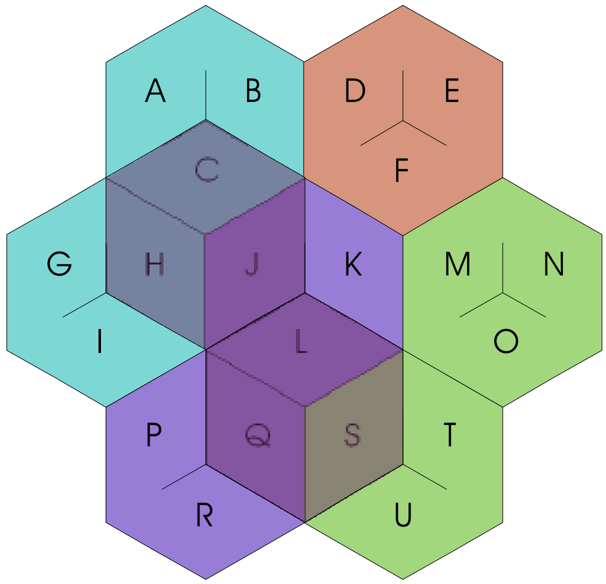

Figure 3 – PE Blade Coverage With Overlap

Figure 3 shows a case in which an additional blade PE has been added to provide overlapping coverage across sectors C, H, J, L, Q, and S. In this case, a VMT in soft handoff using sector-carriers C and H could report sector-carriers A or J as soft handoff candidates. Note that it must not report both A and J because there is no blade PE that can serve both sector-carriers A and J simultaneously.

4.1 Coverage Limits

The extreme case is for the DMTS to allow any soft handoff by providing sufficient overlap between blade PEs. This amounts to having a blade PE for every possible six (or eight) sector-carrier combination, at every frequency. For example, the 21 sector-carrier system above would require:

$$\frac{21!}{(21-6)!6!} = 54264 \text{ blade PEs}$$

and that's just for one frequency! A more modest 8 sector-carrier system would still require 28 blade PEs for complete coverage of the soft handoff possibilities in a single carrier system.

Figure 4 and Figure 5 show how reasonable coverage can be achieved for a 21 sector system using 3 additional blade PEs, for a total of 7.

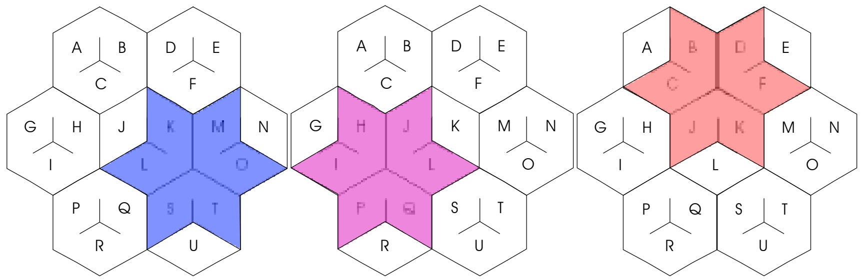

Figure 4 Overlapping Coverage Zones

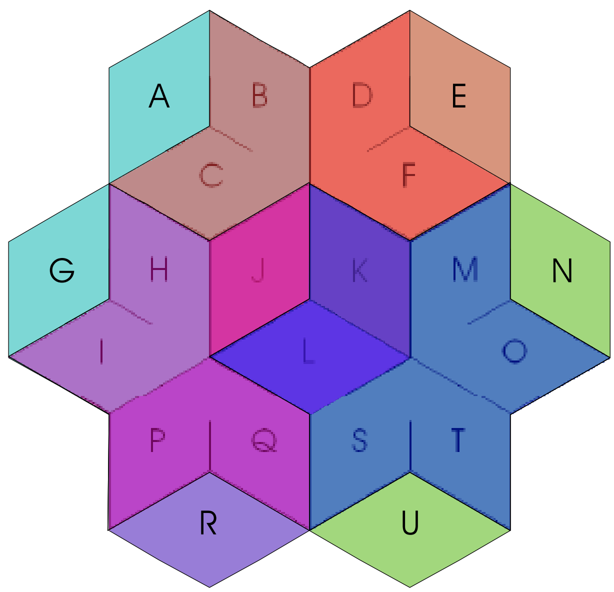

Figure 5 Combined 21 Sector Coverage

The important factor regarding using overlapping blade PEs to reduce soft handoff constraints, is that all constraints cannot be practically removed. Reasonable coverage can be achieve by assuming overlap can be limited to adjacent sectors. However, software support will be required to insure that all pilot reports sent to the network fit within the constraints of the overlapping coverage.