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Applying MSTDM to Packet Voice and Data in Cellular Radio Systems
ICNP '98, Austin Tx, Oct 14-16, 1998.

Viewgraph Sequence

APPLYING MSTDM
to
PACKET VOICE AND DATA
in
CELLULAR RADIO SYSTEMS

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PACKET TECHNOLOGY *in* CELLULAR RADIO

The Number of Users in Cellular Systems is Increasing

The Cell Size Must Decrease to Reuse Frequencies More Often

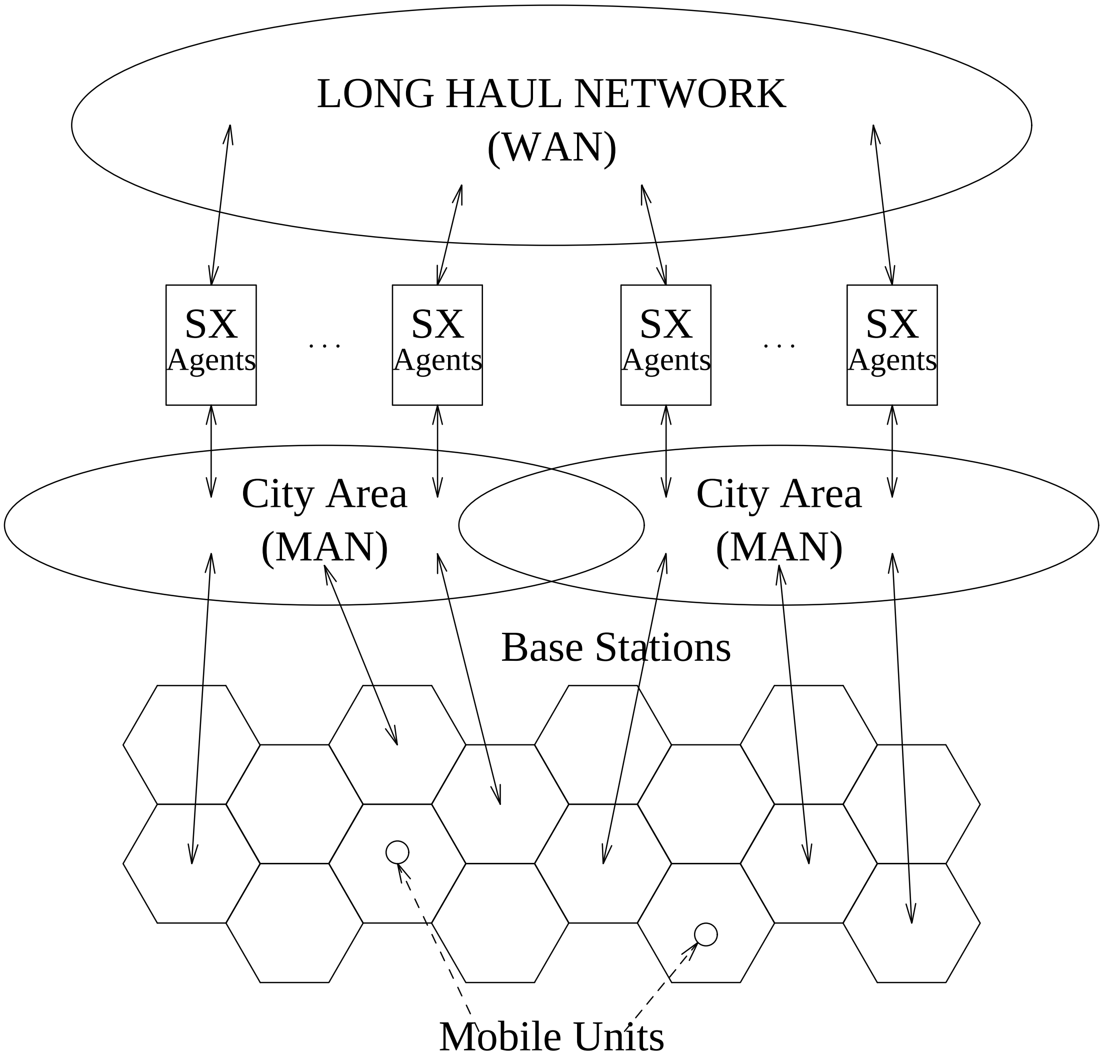
Therefore:

There Are More Hand Offs During a Connection

Packet Technology Can Reduce

1. The Work Performed To Hand Off Between Cells
2. The Probability of Disconnect in a New Cell

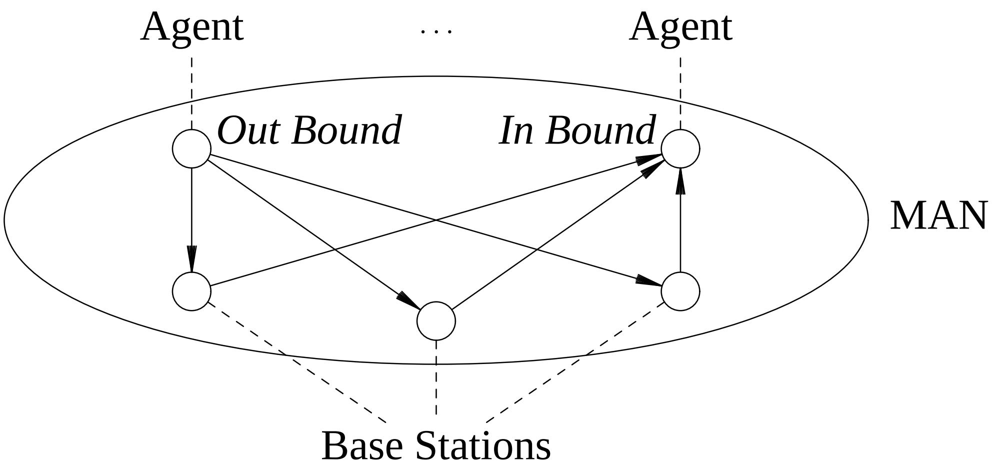
ARCHITECTURE



- **— A Wired MAN Is Needed To Move Between Cells Without Moving In The Long Haul Network**
- **— 5 Different Packet Techniques**

APPLYING PACKET TECHNIQUES

WIRED NETWORK



1) In Bound:

Changing Base Station ⟶ Stationary Agent

Packets Keep The Same Destination Address

2) Out Bound:

Stationary Agent ⟶ Changing Base Station

The Packet Destination Changes As the Mobile Unit Changes Cells

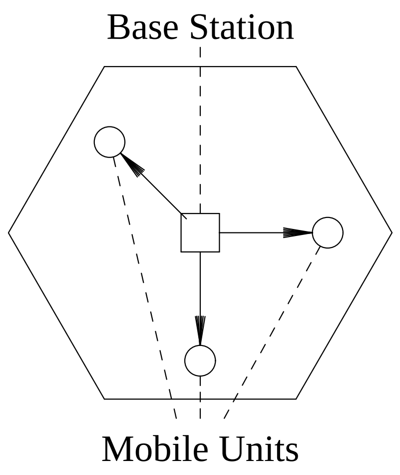
3) CONTROL CHANNEL

Receive Calls, etc.

One Frequency Everywhere - Shared and Reused

APPLYING PACKET TECHNIQUES

WIRELESS NETWORK

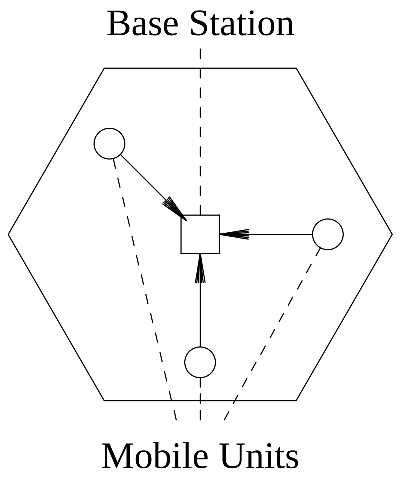


4) Out Bound

One Base Station $\longrightarrow$ Many Mobile Units

Continuous Transmission

Addressed, *ATM-Like* Slots



5) In Bound

Many Mobile Units $\longrightarrow$ One Base Station

Burst Transmission

Multiple Access, Contention Protocol

USEFUL CHARACTERISTICS

1. **Smaller Propagation Delay In A Cell**
   - Enables Carrier Sense Contention Protocols

2. **Each Cell Has A Base Station**
   - Reduces Communication Distance
   - Source of Timing

3. **Connect Mobile Units $\leftarrow\rightarrow$ WAN**
   Not Other Mobile Units

PROGRESSION -- 3 Factors of 2

1. **Base Station Enables 2 Channel CSMA**
   Instead of 1 Channel
   — Increases Frequency Reuse
   — Enables CD for MSTDM, and QOS for Voice

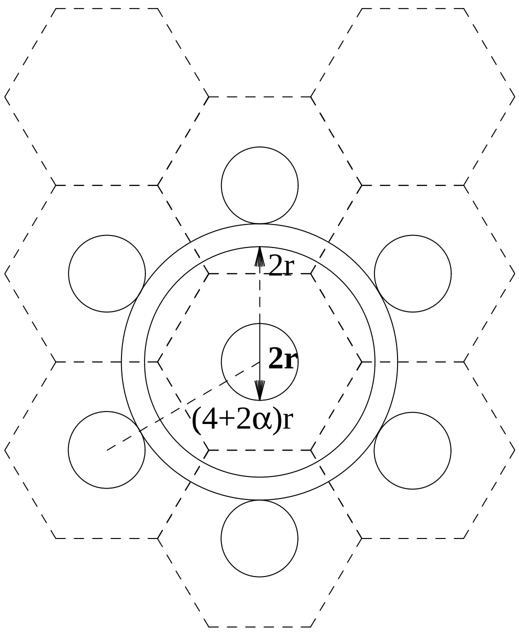
2. **Communicate with WAN instead of Intra-Cell**
   — Eliminates 2nd Channel for MSTDM Variant
   — Mux State on Out Bound Wireless

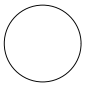
3. **Timing From Base Station -- Minislotted System**
   — Reduce Overhead Bits
   — Quick Access for TASI

SINGLE VRS DOUBLE CHANNEL CSMA

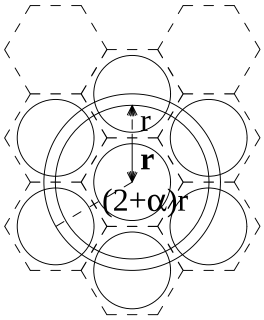
CONSTRAINTS ON FREQUENCY REUSE

One Channel

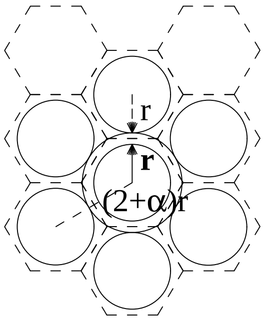


 = SAME FREQUENCIES

Two Channels



Inbound Channel



Outbound Channel

Single Channel: *Channel 1:* Mobile Unit $\longrightarrow$ Mobile Unit

Double Channel: *Channel 1:* Mobile Unit $\longrightarrow$ Base Station,
Channel 2: Base Station $\longrightarrow$ Mobile Unit

2 Times The Frequency, But 1/4 of The Surface

CD Possible On 2^{nd} Channel - *No Echo*

MOVABLE SLOT TDM

ACCESS PROTOCOL

DATA and **INITIAL VOICE PACKET**

CSMA/CD with Random Retry - **Ethernet**

Packet Size Constraint

PRIORITY VOICE

CSMA with Immediate Retry

Next Packet T_P Secs. After Xmit - **Movable Slots**

Pre-Empt Header - Win Collision With Data

Overflow Area - Extra Samples During Delay

GUARANTEE

No Voice Samples Are Lost -- *Even As* $\rho \rightarrow 1$

Proof -- N. F. Maxemchuk, "A Variation on CSMA/CD That Yields Movable TDM Slots in Integrated Voice/Data Local Networks," BSTJ, Vol. 61, No. 7, Sept. 82, pp 1527-1550.

ELIMINATING THE SECOND CHANNEL

Communications: Mobile Units $\longleftrightarrow$ Long Haul Net

Therefore: The Second Channel Is Only Used To Determine The State Of The Contention Channel

Implementation: *Multiplex State Onto Out Bound Channel*

- The Base Station Reports 3 Channel States:
  - Idle, Data Only, and Voice
  - Not True CD $\rightarrow$ MSTDM Variant
- Use DLE's To Interrupt The Out Bound Channel
  - Variable delay $\rightarrow$ Small Probability of Voice Collision
- Send ACK From The Base Station At The End Of A Packet.
  - Use To Detect Collision Between Data Terminals
  - Also Needed For Voice Collisions

THE BASE STATION AS A SOURCE OF TIMING

MINI-SLOTTED MSTDM

Divide Time Into Minislots ≥ R.T.D.

Packet = *k* Minislots

Send State Of Contention Channel At The Minislot Rate -- States: Reserved, Collision, Busy, Idle_Voice, Idle_Any

IMPROVEMENTS

Restores the QoS of Voice

Base Station Reserves Minislot For Next Voice Packet
No Preempt Header

Base Station Detects Collision and Stops Sources
CRC on 1^{st} Minislot -- Voice or Data

Tree Algorithm For Contention Resolution
Priority For New Voice **-- Enables TASI**

CONCLUSION

The Need To Decrease Cell Sizes in Radio Networks Will Make It Possible To Use CSMA To Share The Channel

By Taking Advantage Of The Characteristics Of Cellular Radio Systems, We Can Obtain:

- Up To 8 Times The Throughput Of Standard CSMA
- Quality Of Service Guarantees For Voice
  Using MSTDM
- Up to 4 Times The Throughput of Standard MSTDM
  As Applied To Ethernet And CATV Networks.