Multiple Layered Method of Terminal Slot Contention Resolution for the Integrated Waveform (DAMA UHF SATCOM)

Richard Booton
Principal Engineer, Harris RF Communications

OVERVIEW

- Introduction
- Integrated Waveform (IW)
- Slot Contention
- Basic Service Selection Protocol
- Layered Approach to Slot Contention Resolution
  - Dynamic Service Selection Protocol
  - Priority Based Command Filtering Protocol
  - Command Collision Avoidance Protocol
- Summary
- Questions

INTRODUCTION

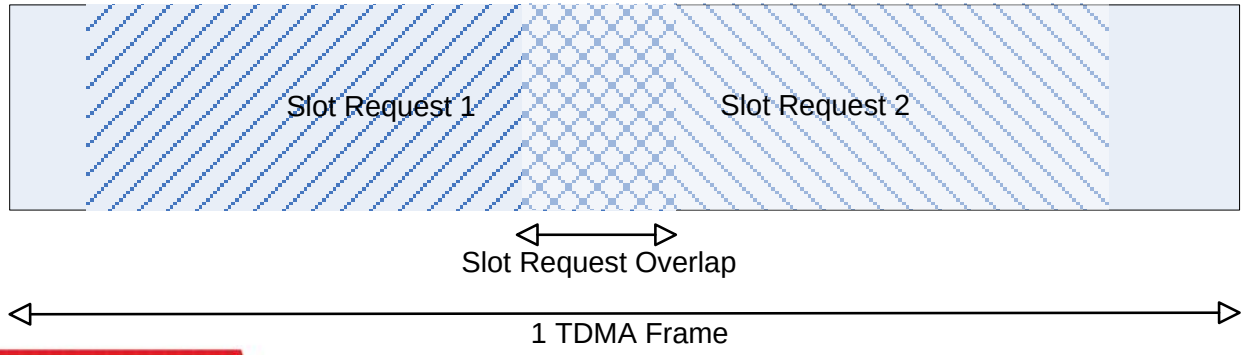
- Utilization of geostationary satellites.
  - Enables beyond the line-of-sight communications.
  - Enormous deployment costs.
- Employment of time division multiple access.
  - Splitting of channel bandwidth into timeslots.
  - Distribution of timeslots as services.
  - Minimal degradation in performance.
- Growing disparity between supply and demand.
  - Increasing requirements for satellite channel access.
  - Degradation of existing satellite resources.
  - Additional satellite channel resources years away.

INTEGRATED WAVEFORM (IW)

- Stopgap measure until MUOS deployed.
  - Improves the utilization of the existing UHF MILSATCOM constellation
- Multi-h continuous phase modulation (CPM).
  - Allows more services to be allocated within a single satellite channel than with the legacy DAMA protocol
- Elimination of service configuration and channel format restrictions
  - Ability to select from a nearly limitless number of multiple-access service configurations
  - Reuse of channel space that has been historically wasted while utilizing the legacy DAMA protocol

SLOT CONTENTION

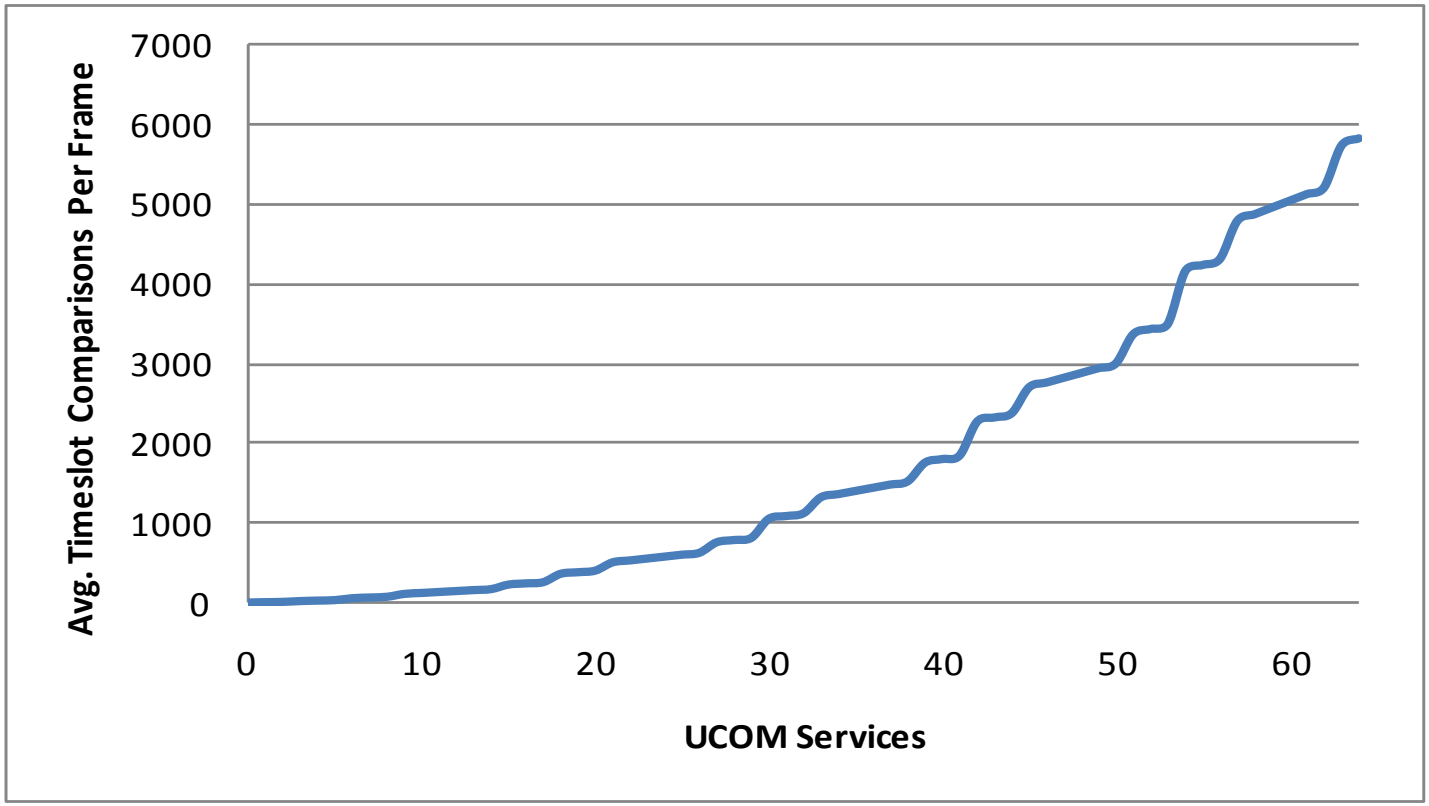
- Occurs when the timeslot position of two or more services prevents simultaneous utilization
  - Interference with Downlink or Uplink acquisition
- Effect of service placement flexibility on the probability of slot contention
  - Increases the possibility that one or more services will contend
- Increased service allocation complexity
  - Selection of the first available and contention-free timeslot position
- Effects the ability to allocate future services
  - Selection of non-bandwidth optimal timeslot positions



BASIC SERVICE SELECTION PROTOCOL

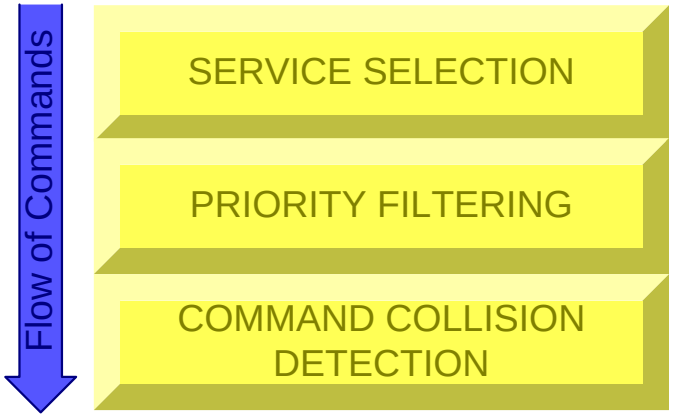
- Terminals need Downlink and Uplink services when operating in IW
  - Services selected that avoid slot contention with the UCOM services on the terminal's guarded service list
- Terminal reevaluates the selection of services that will be utilized before the beginning of each frame
  - Subsequently schedules the entire frame's worth of timeslots at once
- Minimum computational complexity of $O(i * j * k)$
  - Where i is the of the number of Uplink services, j is the number of k Downlink services, and is the number of guarded UCOM services

BASIC PROTOCOL COMPUTATIONAL COMPLEXITY



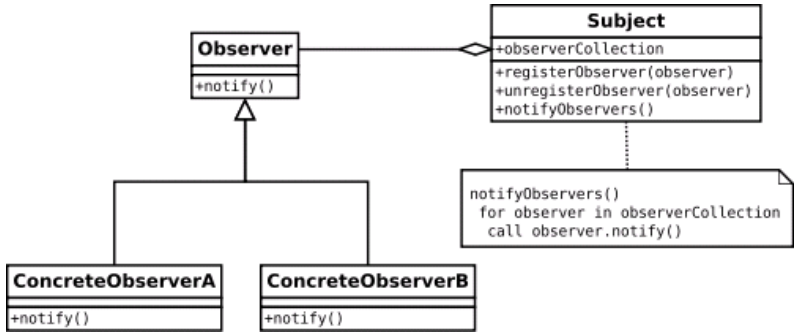
LAYERED APPROACH TO SLOT CONTENTION RESOLUTION

- Dynamic service selection protocol
  - Distributed system knowledge and control
  - Selection of the best combination of services
  - Registration for pertinent services type notifications
  - Reevaluation of service selection on system changes
- Priority based command filtering protocol
  - Maintains database of outstanding modem commands
  - Aborts lower priority commands as necessary
  - Simulates appropriate response for filtered commands
- Command collision avoidance protocol
  - Dynamically adjusts parameters of adjacent commands
  - Forcibly completes commands in progress

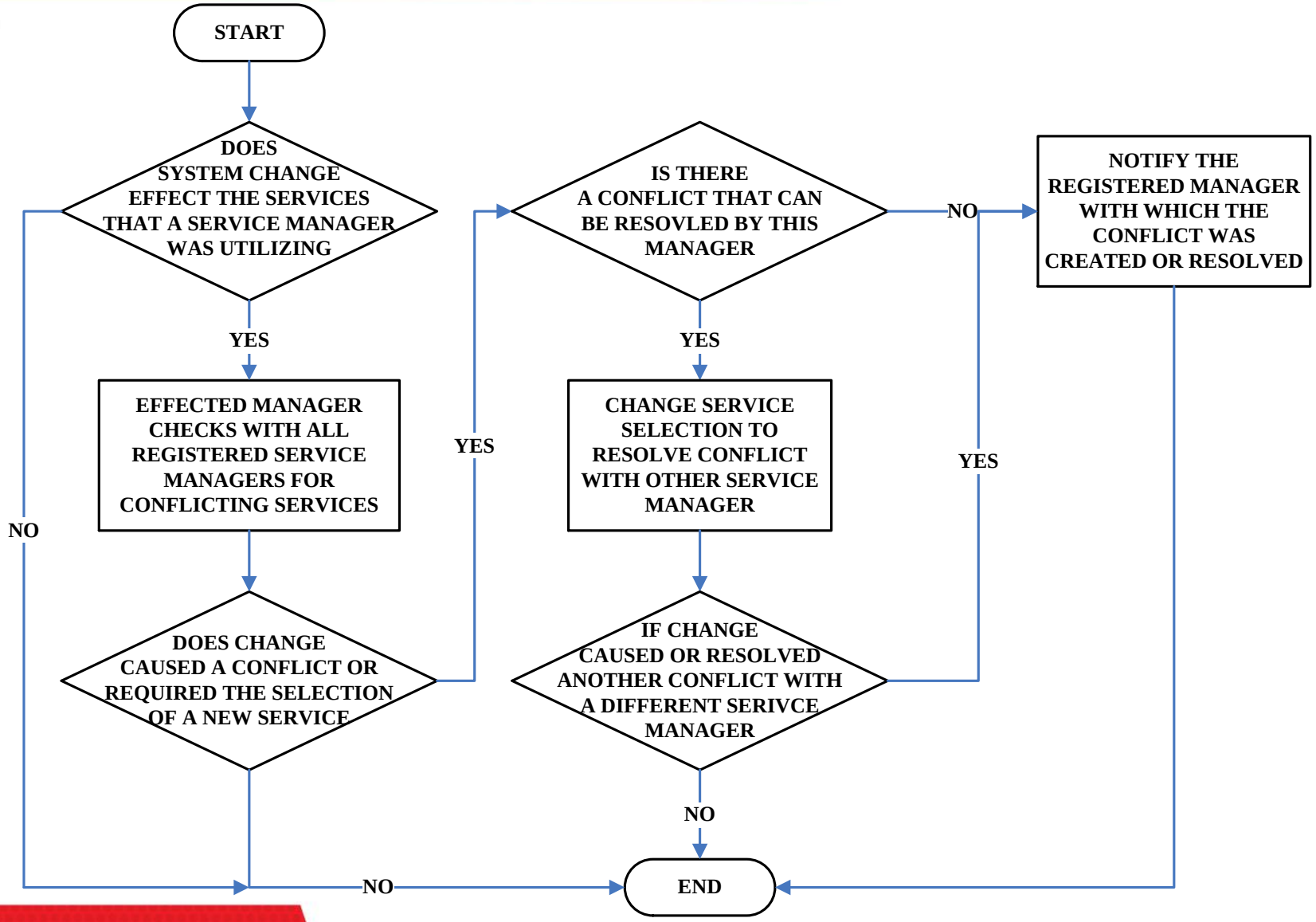


DYNAMIC SERVICE SELECTION PROTOCOL

- Evaluate slot contention only when changes are made to that could directly impact service selection
  - Enables the use of distributed service management
  - Reevaluation of slot contention only when changes are made to services that a particular manager using
- Service managers register with a notification service to limit communication between managers
  - Reduces thrashing of service selection
- Service mangers can attempt to utilize services that occupy overlapping timeslots
  - Only if there are no other non-contending options



DYNAMIC SERVICE SELECTION PROTOCOL STATE MACHINE

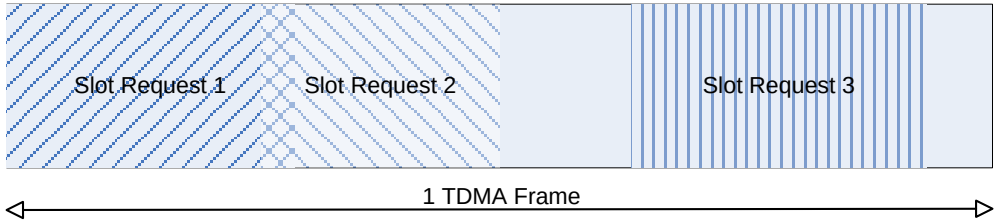


PRIORITY BASED COMMAND FILTERING PROTOCOL

- Additional interface added to resolve cases when overlapping receive and transmit commands are issued to the terminal's modem implementation
  - Maintains database of start time, end time, and type of each outstanding receive or transmit command
- Compares the start and end time chip of each new command to each currently scheduled receive or transmit command
  - Aborts lower priority commands if an overlap is found between a new command and one already scheduled
  - Simulates appropriate modem response for filtered commands
    - Allows manager to select another service that does not contend
    - Prevents the abort from being treated as a modem implementation failure and causing system issues

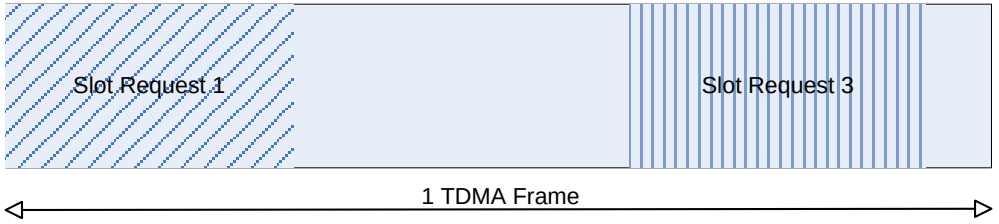
PRIORITY BASED COMMAND FILTERING PROTOCOL

- Overlapping TDMA Timeslot Requests



Slot 2 Filtered Due to Overlap

- Timeslot Requests after Filtering

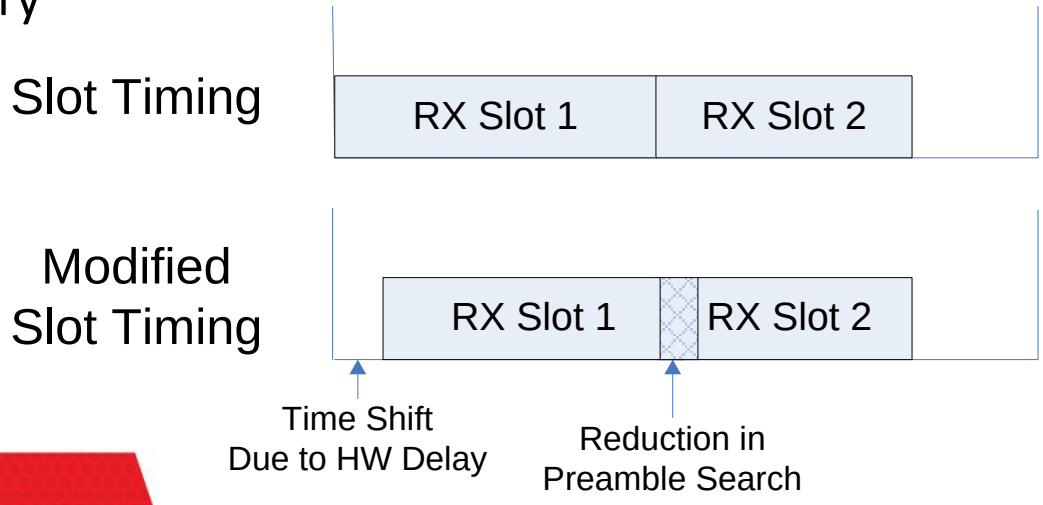


COMMAND COLLISION AVOIDANCE PROTOCOL

- IW protocol is a multi-channel TDMA protocol
  - Terminals must utilize two or more services that are placed adjacent to each other
- IW protocol was designed to enable the maximum usage of a given set of TDMA SATCOM channels
  - Very little turnaround time was allotted to between adjacent timeslots
  - Older terminals do not possess the necessary hardware to meet these new requirements
- Issue of adjacent timeslots can be simplified by categorizing all commands as transmit or receive
  - Reduced to four cases (Rx-to-Rx, Tx-to-Rx, Rx-to-Tx, Tx-to-Tx)

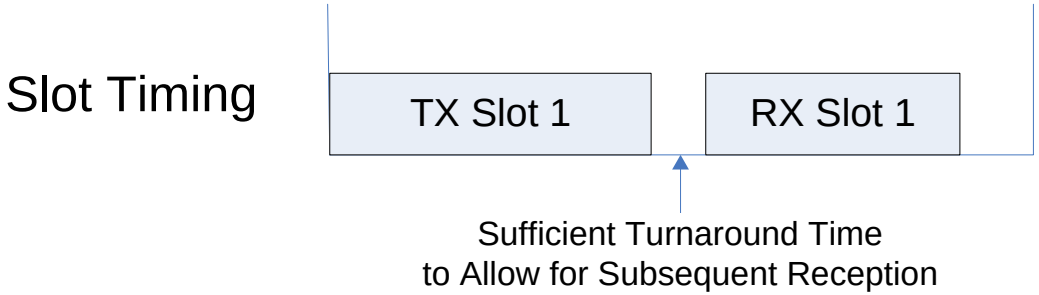
RX-TO-RX TIMESLOT HANDLING

- Reception of the first timeslot can begin to intrude on the second timeslot preamble search window
  - The transmitter of the first service is beginning to drift towards the edge of the allowable guard window
- Begin the reception of the second timeslot immediately after the first timeslot has completed
  - Shorten the search window for the second services preamble when the first service is still in the process of demodulating
- Force any remaining data through the receive filters of the terminal if necessary



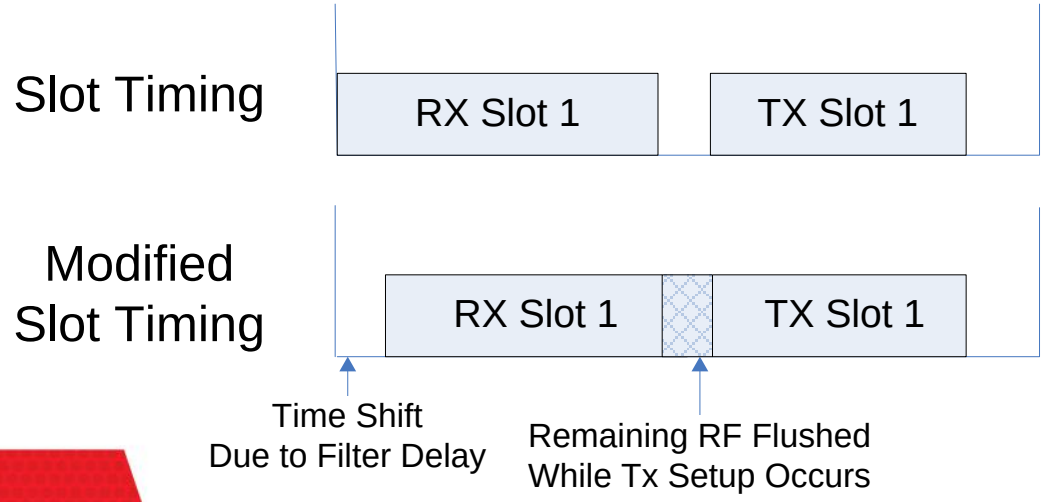
TX-TO-RX TIMESLOT HANDLING

- IW specification accounts for this type of scenario by providing additional turnaround time when either timeslot is transmit
  - The transmit burst can't be aborted early without harming the ability of another terminal to receive it
- Pend the subsequent receive command until the first command has finished transmitting
  - Shorten the search window for the second services preamble if the first service is still transmitting like in the Rx-to-Rx case



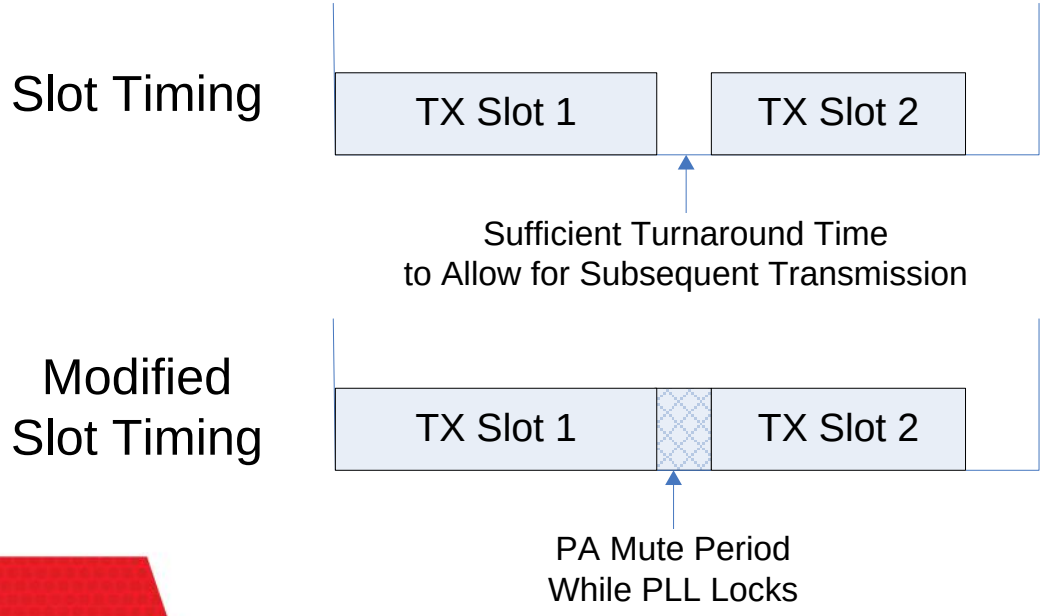
RX-TO-TX TIMESLOT HANDLING

- Similar to the receive-to-receive scenario
  - The IW specification has allocated some additional turnaround time before the transmit request
  - It still may be necessary to begin setting up the terminal hardware for the transmit burst while the terminal is still attempting to receive
- Force any remaining data through the receive filters of the terminal if necessary
  - Receive path of the terminal should have already sampled all of the necessary data from the antenna



TX-TO-TX TIMESLOT HANDLING

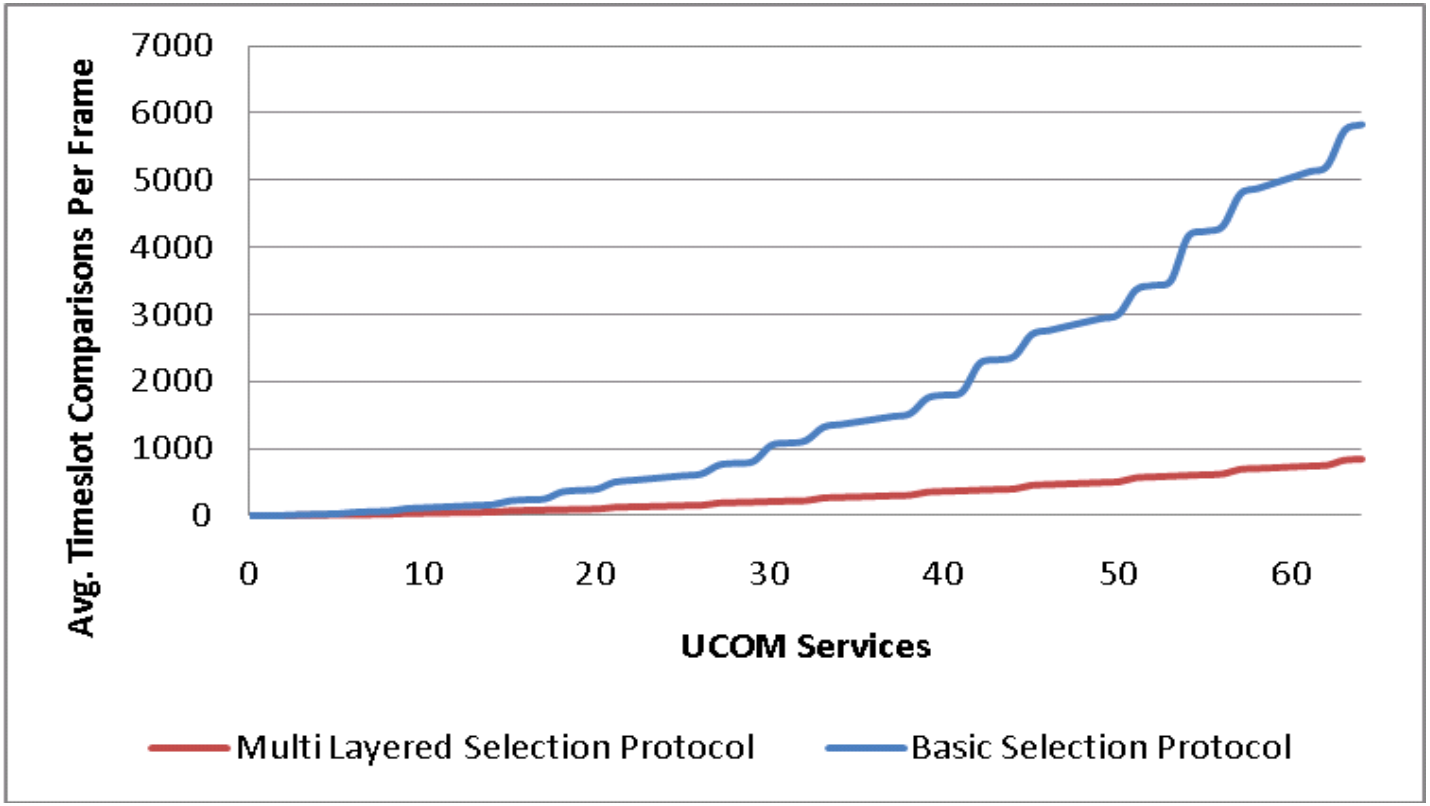
- Only limitation is terminal's ability to stop Txing and configure for another frequency before the next Tx slot
  - The IW specification has allocated some additional turnaround time before the transmit request
- The terminal can concatenate the two Tx slots into a single burst
  - Change frequencies if necessary during the turnaround time
  - Inhibit the PA during the span of time between the adjacent transmit timeslots to prevent stray RF



SUMMARY

- The Integrated Waveform
  - Improves the communications capabilities of the existing UHF MILSATCOM constellation.
- Slot contention
  - Hinders the efficient allocation of services
- Basic Service Selection Protocol
  - Terminal reevaluates the selection of services that will be utilized before the beginning of each frame
  - Minimum computational complexity of O(i * j * k)
- Layered Approach to Slot Contention Resolution
  - Limits frequency of system revaluations
  - Permits a more stable service selection protocol
  - Enables the simultaneous usage of adjacent timeslots
  - Reduces computational complexity by an order of magnitude

COMPARISON BETWEEN BASIC AND MULTI LAYERED SELECTION PROTOCOLS



QUESTIONS?

BACKUP MATERIAL

TDMA FRAME STRUCTURE