



WiMedia Media Access Control (MAC)

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Agenda



- Key Messages
- Relationship of Certified Wireless USB and other WiMedia Specifications
- WiMedia MAC 1.0 specification overview
 - Details frame formats
 - Details on the use of MAC device address and EUI-48 addresses
 - Details on beacons and synchronization
 - Details on dynamic reservation protocol (DRP)
 - Details on the Use of private reservations
 - Overview on security and the use of encryption offset
- Summary
- Q & A

Key Messages



- This session will teach vendors & manufacturers what they need to know to implement WiMedia MAC features into their product
 - Focus on information that developers of Certified Wireless USB hosts, devices, and dual role devices need to understand
 - Provide detailed examination of key features of the finalized WiMedia MAC 1.0 specification (also now [ECMA-368](#))

High Level Overview of MAC Capabilities



- Mobility
 - Allows devices maintain connectivity as they move across network boundaries in which networks merge and split
- Simultaneous Operating Piconets (SOP) Performance
 - Allows independent Piconet to have distributed coordination to remove the problem of devices in different Piconets interfering with each other
- Support for isochronous and asynchronous data
 - Prioritized access for both types

WiMedia MAC Fundamentals



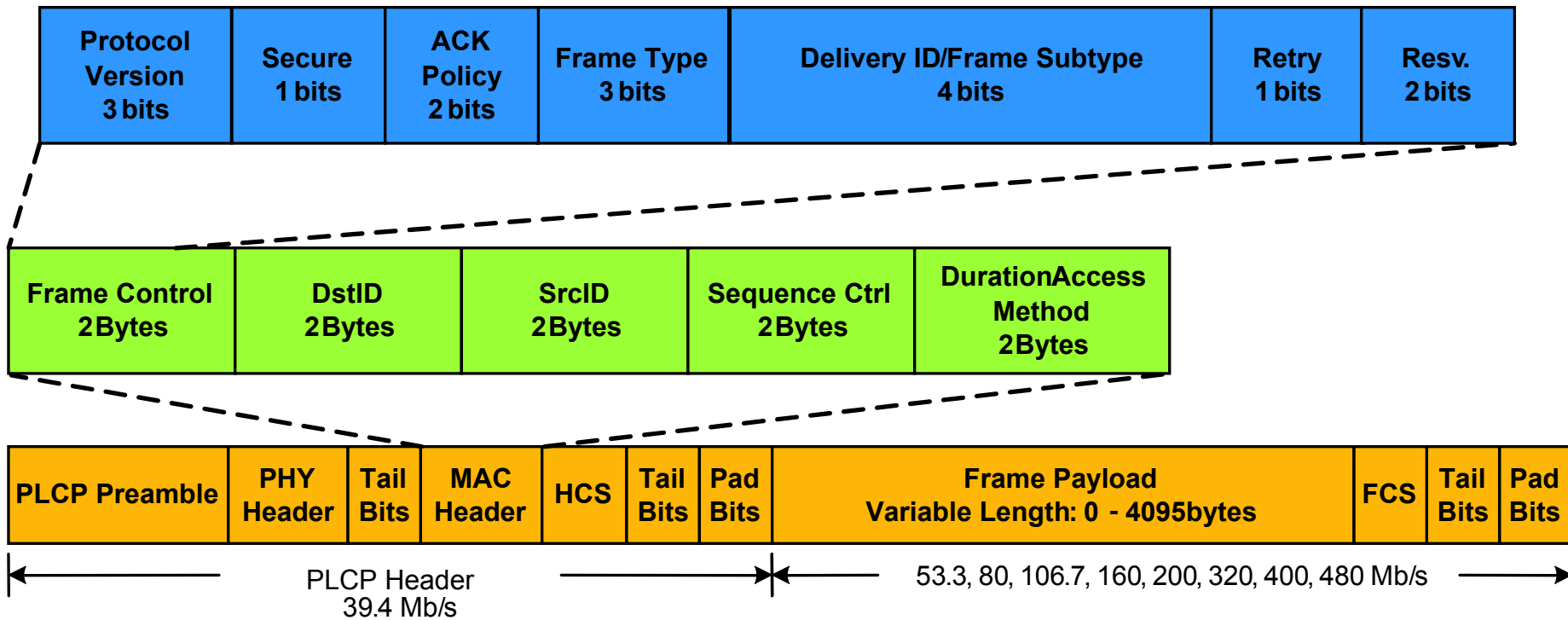
- Decentralized PAN Operations
 - Every device beacons during the beacon period at the begin of the superframe (65ms) and access control is decided by each device
 - Rest of the superframe is for data transfers
 - Beacon slot occupancy info in each beacon to detect hidden node problem
 - Distributed Reservations ensures Quality of Service (QoS) Support

MAC Fundamentals (Cont.)

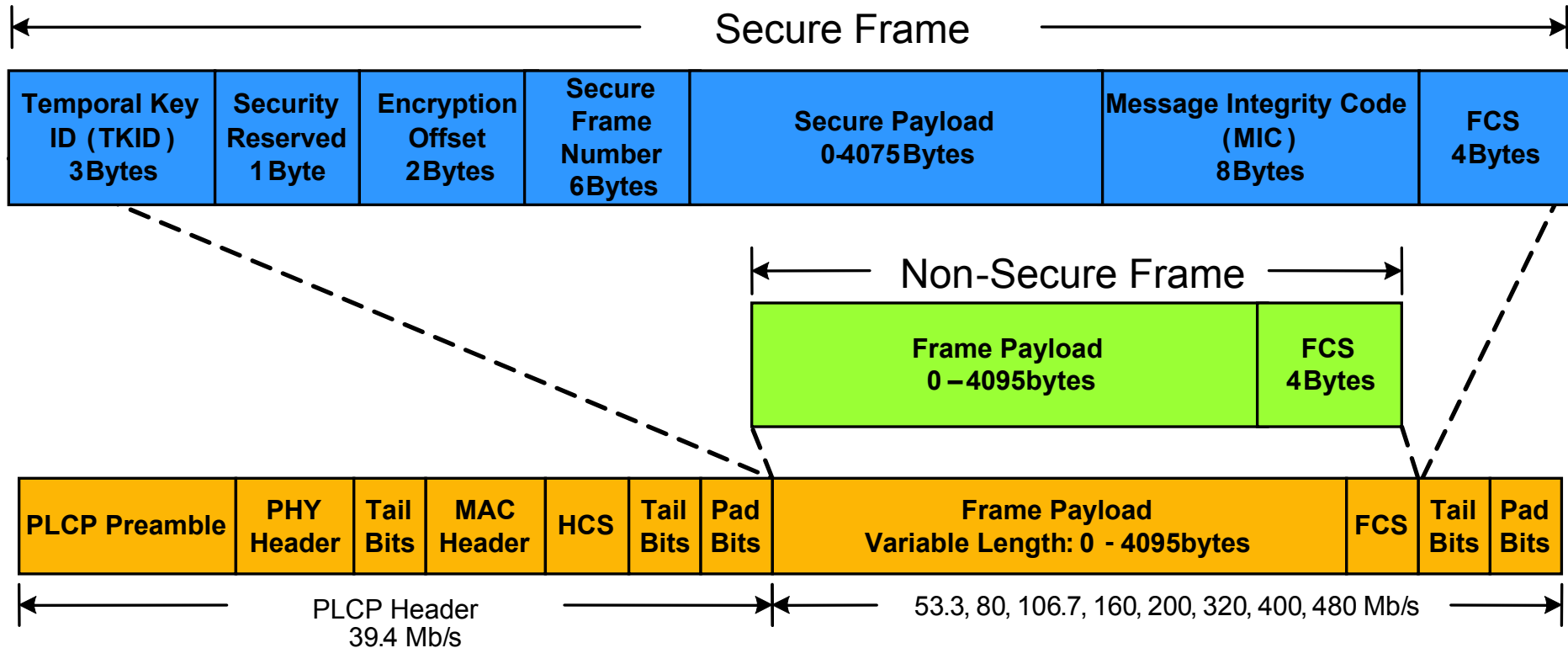


- Combination of Carrier Sense Multiple Access (CSMA) and Time Division Multiple Access (TDMA)
 - Distributed Reservation Protocol (DRP) is used to reserve the medium for isochronous or other traffic and provides the TDMA access
 - Reservations are announced in the beacons
 - For CSMA access Prioritized Contention Access (PCA) based on Enhanced Distributed Channel Access (EDCA), with mapping of 802.1d user priorities to MAC access priorities
 - Uses Ready to Send (RTS) and Clear to Send (CTS)

WiMedia MAC Header

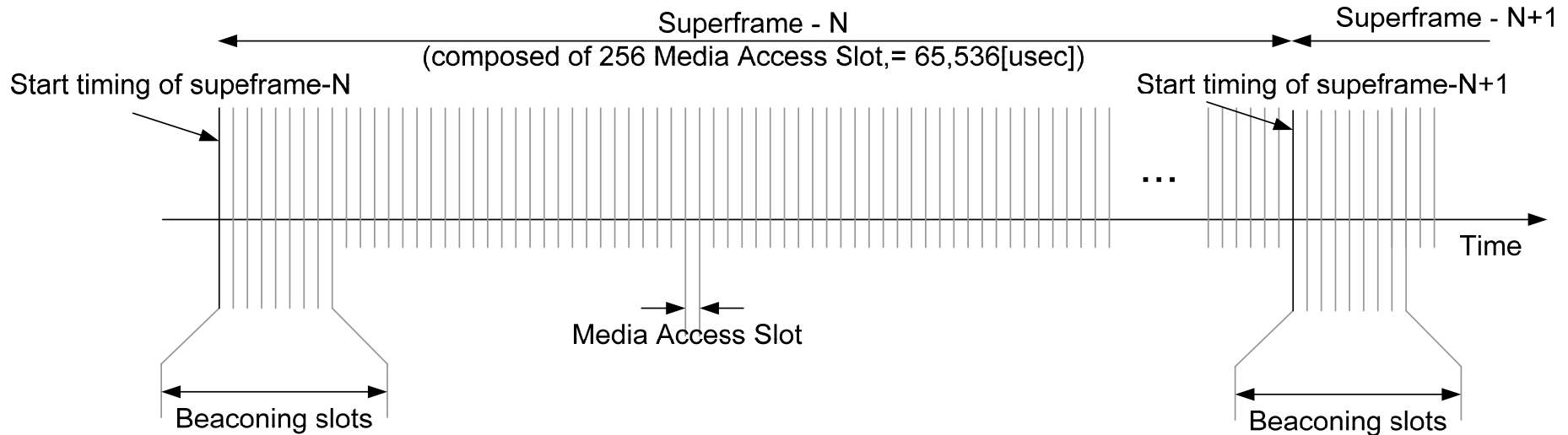


Non-Secure and Secure Frames



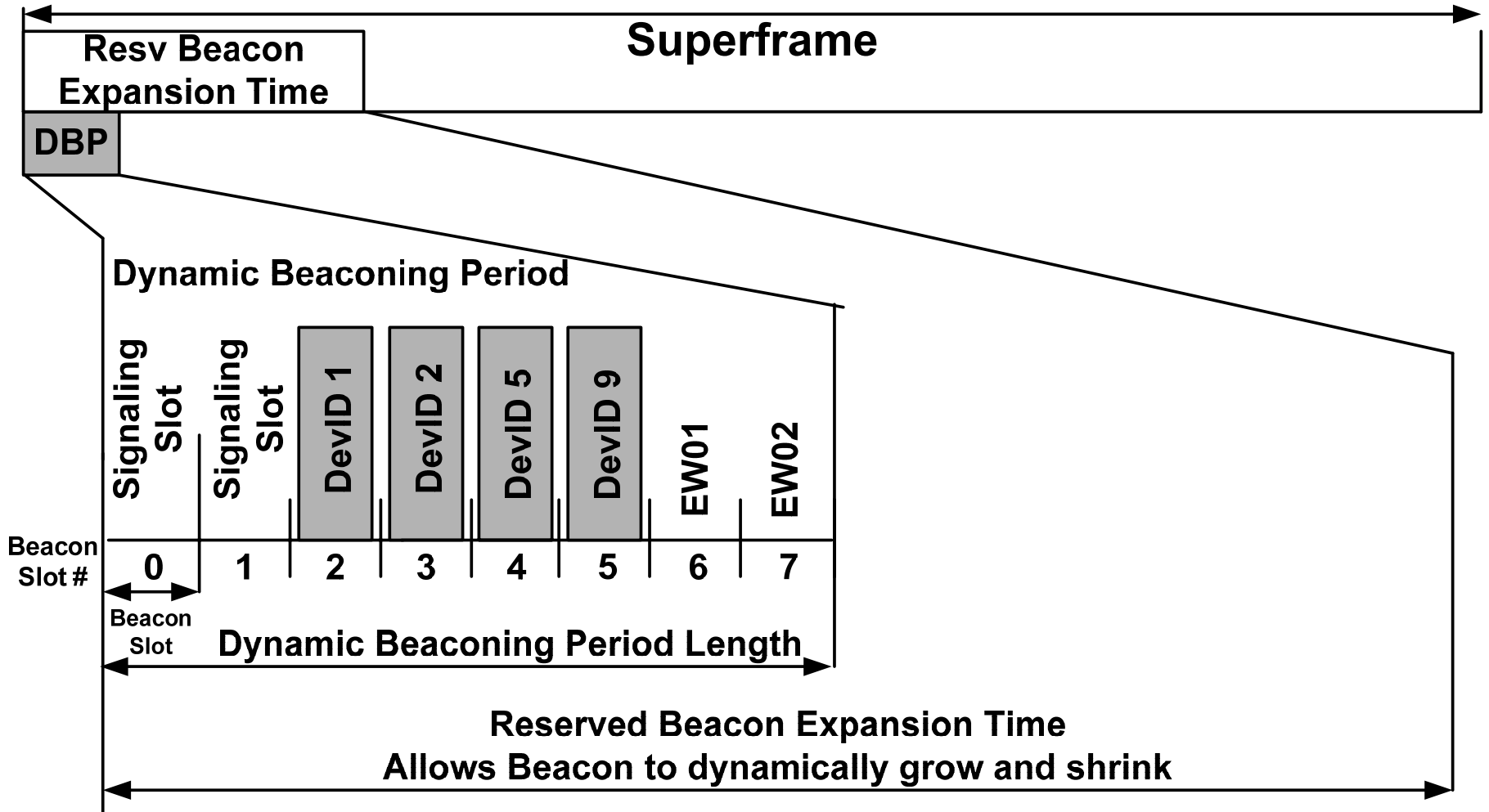
- Secure frames provide encryption and integrity checks
- Non-Secure frames are clear text with no integrity checks

Superframe



- Media Access Slot (MAS) is 256 us
- 256 MAS per Superframe

Beaconing Period (BP)



Beaconing

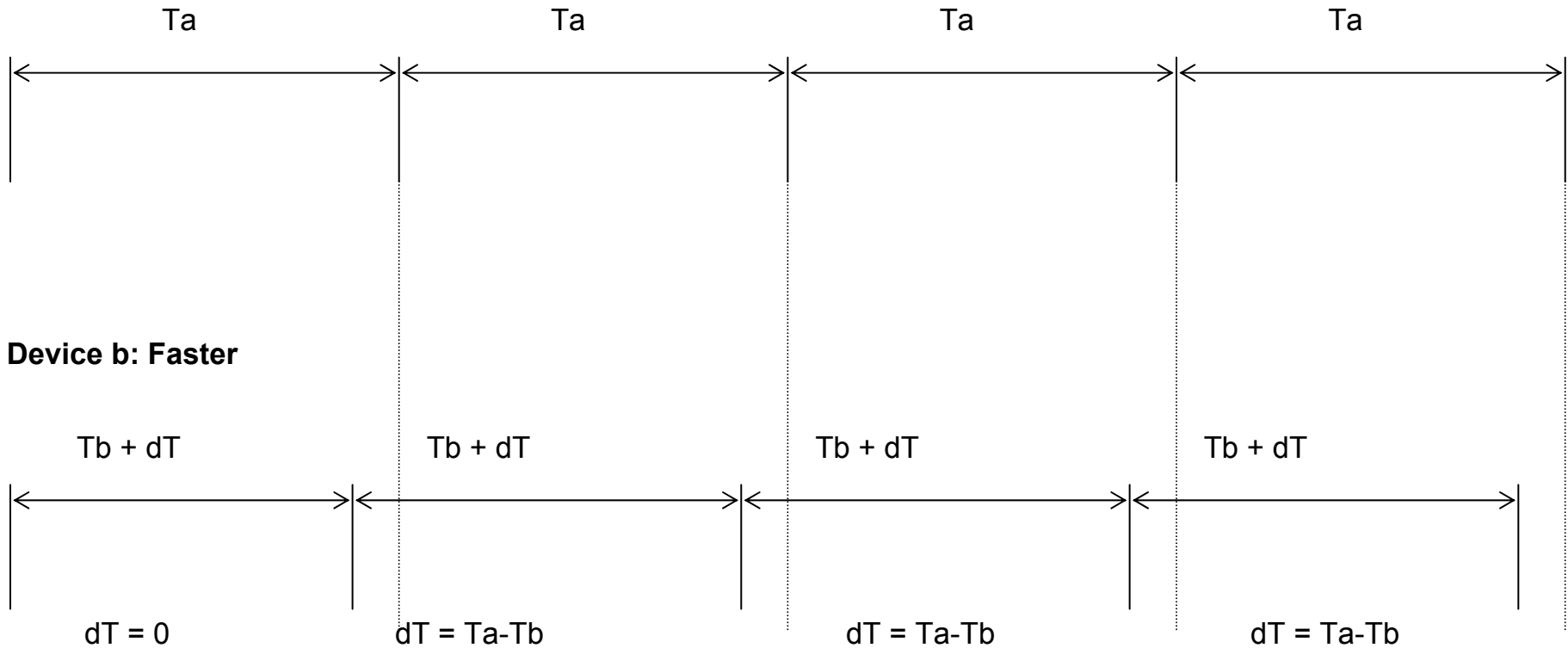


- How it works:
 - First, the device scans channels for beacons
 - If no beacons are received...
 - Then creates its own BP and sends the first beacon
 - If another beacon is received
 - Looks for Extended Window Slots
 - Once a slot is chosen, the beacon use the same slot until the BP can be compressed or unless a collision is detected
 - All devices, which are not sleeping, send beacons

Superframe Synchronization

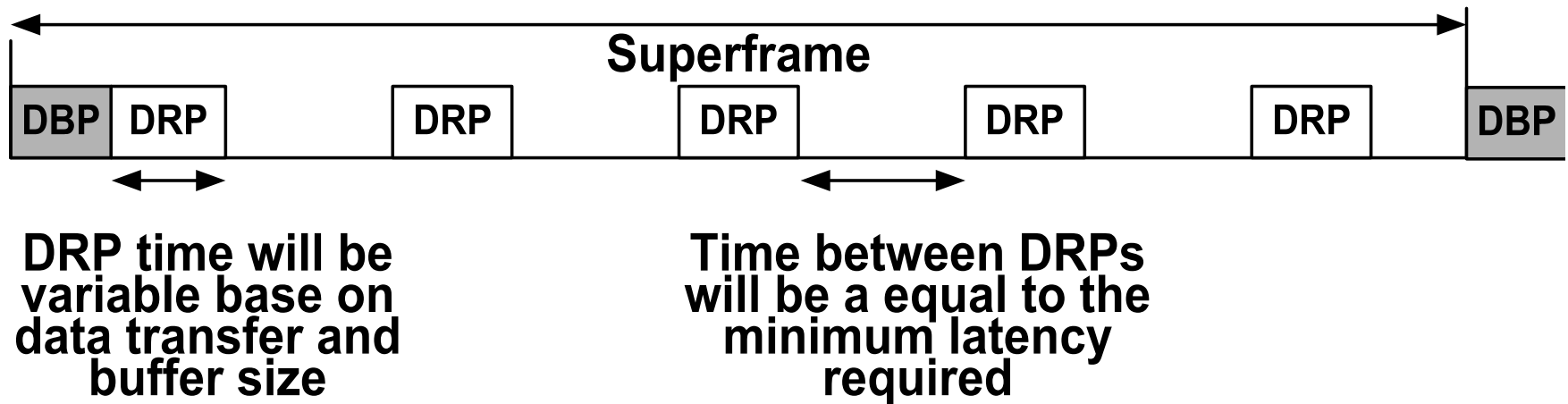


Device a: Slower



- Clock Synchronization done using expected Beacon arrive time

DRPs



- Reserve the medium for isochronous or other traffic
- Provides QoS Support

DRPs (Cont.)



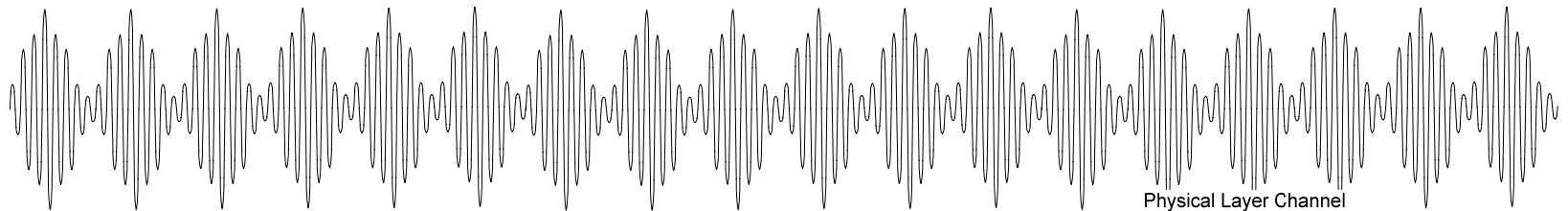
- Reservations are negotiated for multiple Superframes until they are removed
- Hard Reservations
 - Reservations must be explicitly released by Unused DRP Announcement/Unused DRP Response (UDA / UDR)
- Private Reservations
 - Used by Certified Wireless USB
 - Reservations must be explicitly released by Unused DRP Announcement/Unused DRP Response (UDA / UDR)

DRPs (Cont.)



- Soft Reservations
 - Accessed by PCA method
 - Owner of reservation has Highest priority
 - If they are not used can be reclaimed by neighbors
- PCA Reservations
 - Accessed by normal PCA method
 - If they are not used can be reclaimed by others

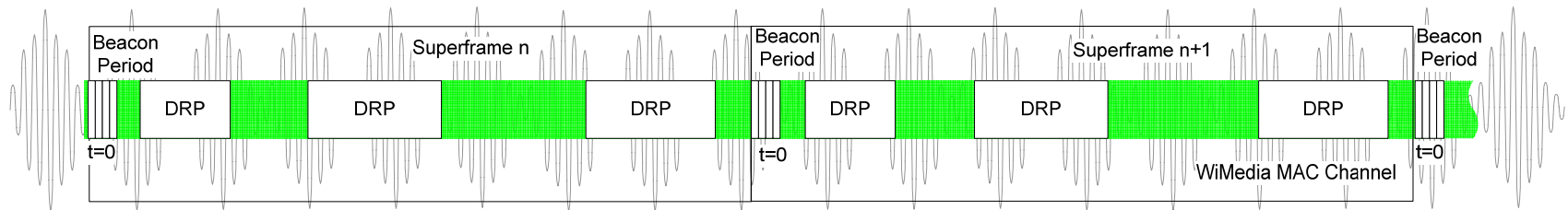
WiMedia PHY Channel



Physical Layer Channel

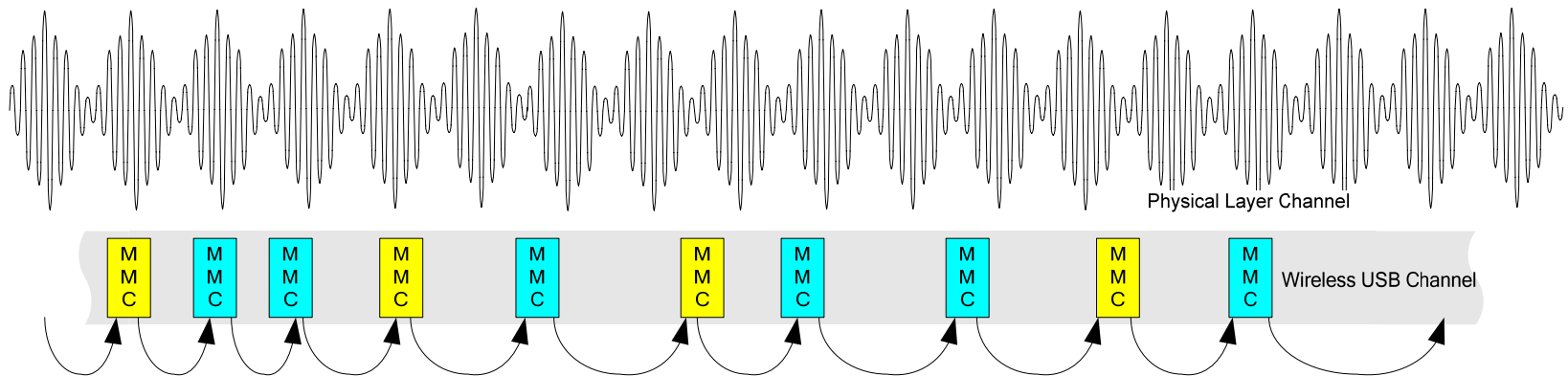
- The Physical Layer communications channel is a sequence of symbols in a frequency band

WiMedia MAC Channel



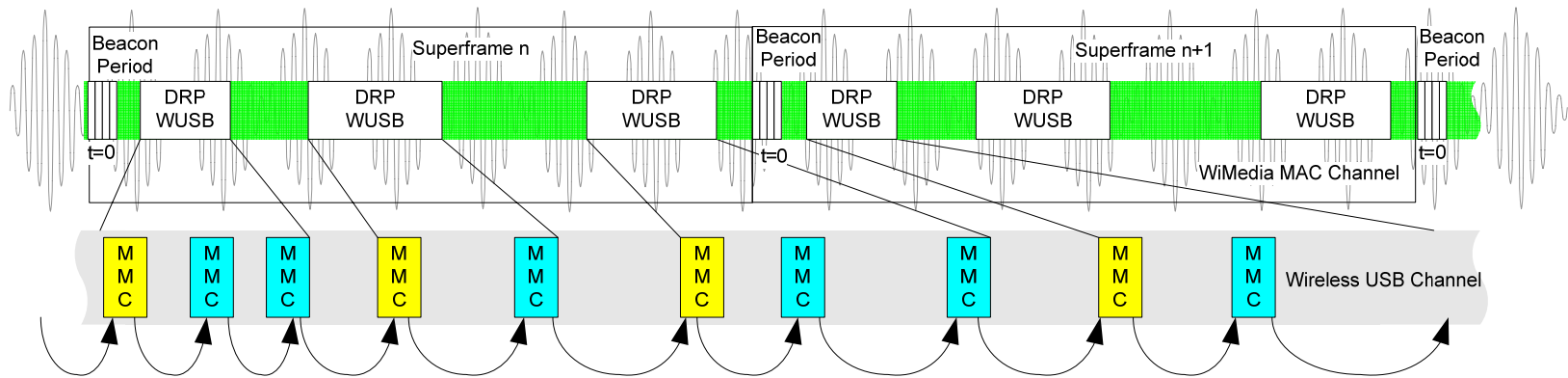
- The WiMedia MAC defines a repeating superframe over the PHY channel
- Reservations can be established in the WiMedia MAC channel

Certified Wireless USB Channel



- Certified Wireless USB MAC defines a monotonically increasing channel time
- Linked list of MMCs occupy the Certified Wireless USB channel

Channel Coexistence



- WUSB channel can be mapped onto a set of WiMedia MAC reservations on the same WiMedia PHY channel
- Certified Wireless USB logo/certification will enforce the mapping



WiMedia MAC Policies

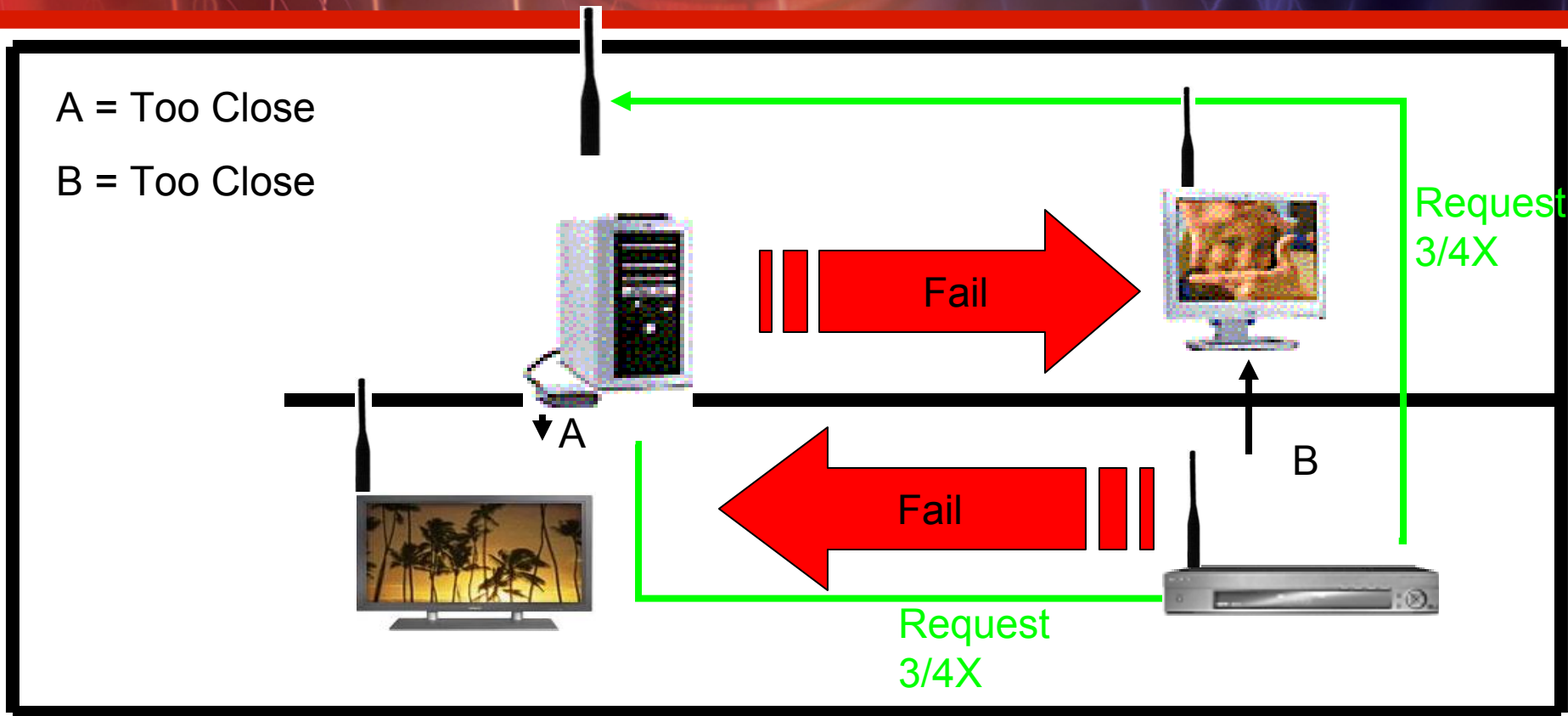
Meet Joe User



Joe runs a graphics art business out of his home office

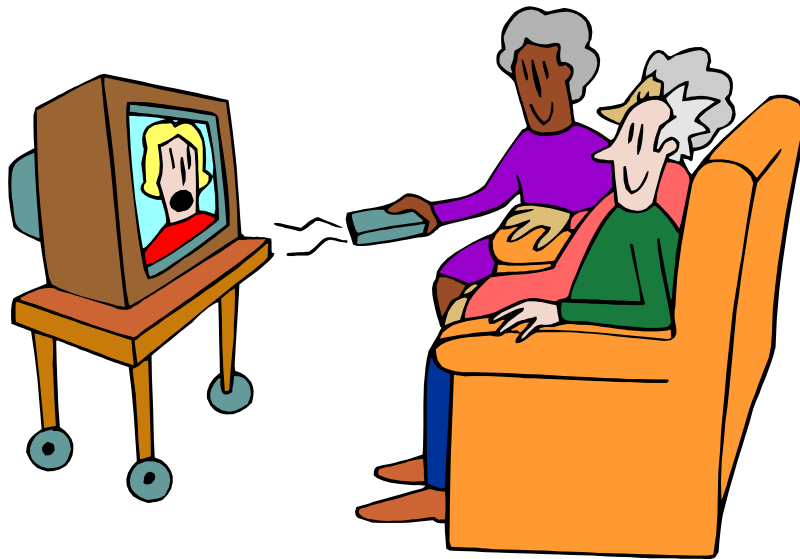
PC monitor resolution is critical

More Bandwidth Required Than Available at Joe's House



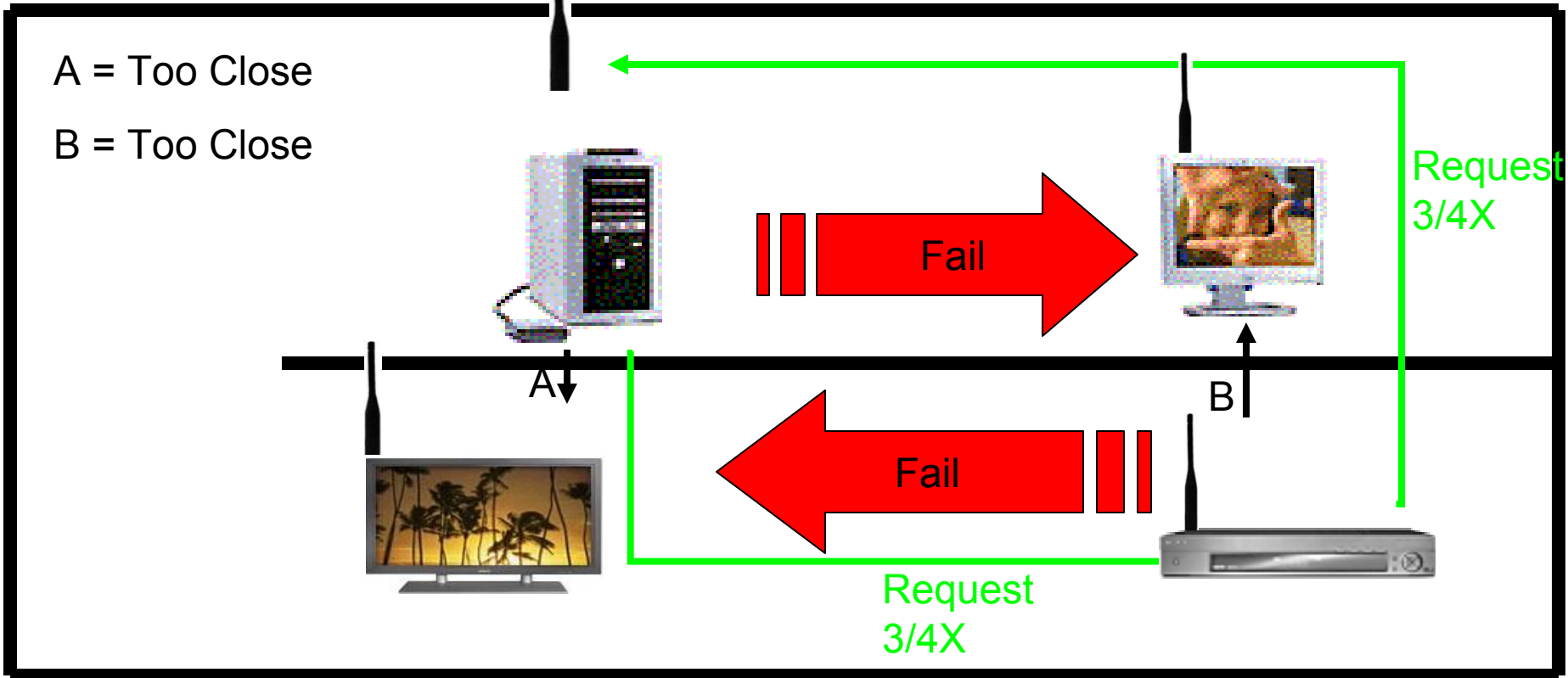
Joe always wants his monitor to get maximum resolution.
How does Joe get what Joe wants?

Meet Jane User



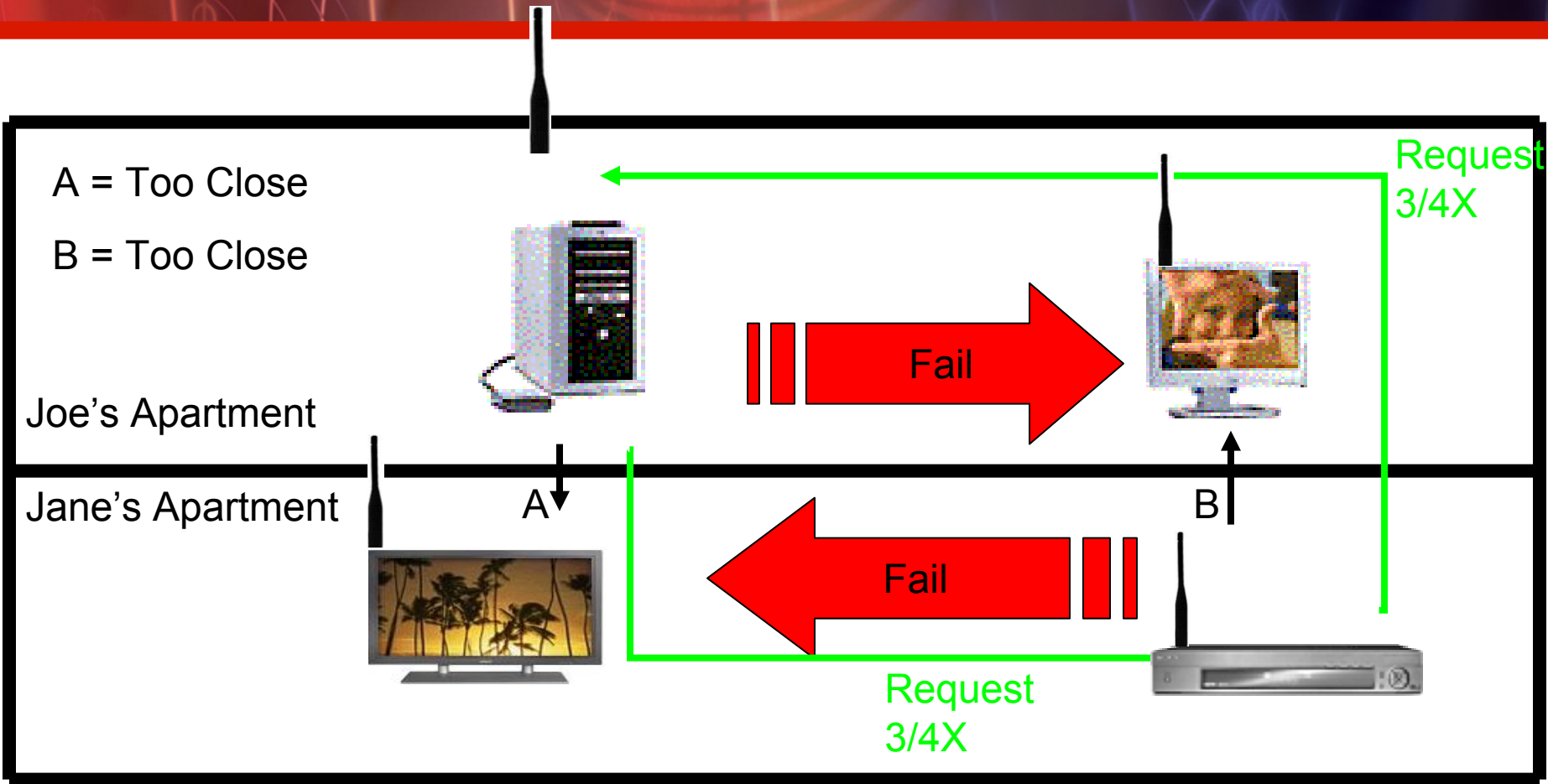
Jane is a videophile that cares passionately about HDTV resolution

More Bandwidth Required Than Available at Jane's House



Jane always wants her HDTV to be operating at maximum resolution.
How does Jane get what she wants?

Multiple Users



Now what? Only fair outcome is $\frac{1}{2}$ each?

WiMedia MAC Allocation Limits Policy



- A device can take any available reservation at any time
- A device can not maintain more than approximately half the MAS (112) on a channel under contention
- Devices should be able to provide some level of functionality with approximately half the bandwidth on the channel
- Policy is designed to allow at least two high bandwidth links to operate on the same channel in most circumstances
- Addressing how bandwidth should be shared between multiple pairs of the same user's devices is outside the scope of WiMedia policy

Device Reservation Types

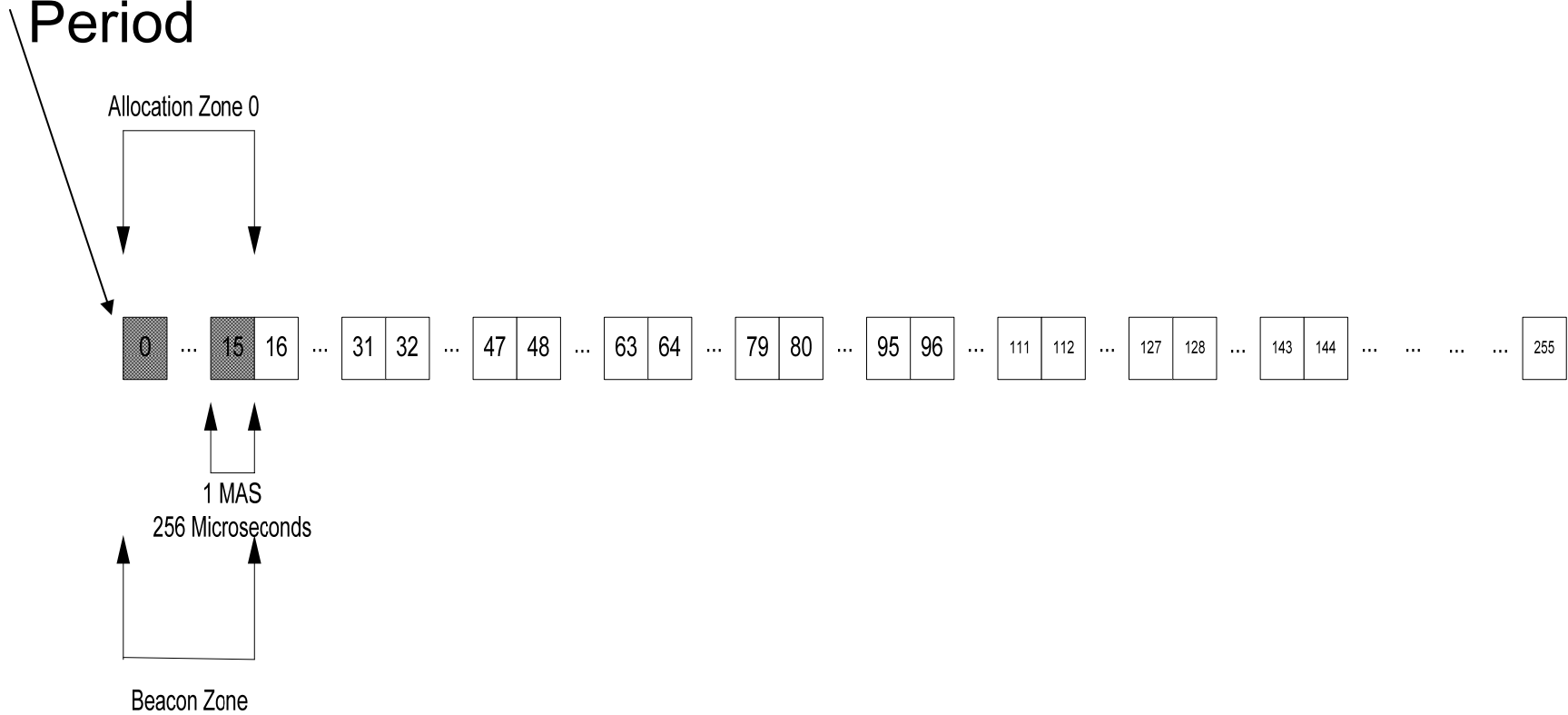


- Low Latency devices prefer or need MAS that are evenly spaced throughout the superframe
- Power Conscious devices prefer a small number of groups of contiguous MAS
- There are devices that have both power and latency concerns
- How do all these devices coexist on the same channel?

Superframe – 1d View

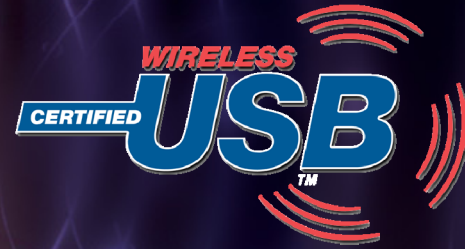


Start of Beacon Period



1d view of Superframe is difficult to use in describing full bandwidth allocation strategies

Superframe – 2d View



		Allocation Zones															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Coordinated MAS Sets	0	0	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
	1	1	17	33	49	65	81	97	113	129	145	161	177	193	209	225	241
	2	2	18	34	50	66	82	98	114	130	146	162	178	194	210	226	242
	3	3	19	35	51	67	83	99	115	131	147	163	179	195	211	227	243
	4	4	20	36	52	68	84	100	116	132	148	164	180	196	212	228	244
	5	5	21	37	53	69	85	101	117	133	149	165	181	197	213	229	245
	6	6	22	38	54	70	86	102	118	134	150	166	182	198	214	230	246
	7	7	23	39	55	71	87	103	119	135	151	167	183	199	215	231	247
	8	8	24	40	56	72	88	104	120	136	152	168	184	200	216	232	248
	9	9	25	41	57	73	89	105	121	137	153	169	185	201	217	233	249
	10	10	26	42	58	74	90	106	122	138	154	170	186	202	218	234	250
	11	11	27	43	59	75	91	107	123	139	155	171	187	203	219	235	251
	12	12	28	44	60	76	92	108	124	140	156	172	188	204	220	236	252
	13	13	29	45	61	77	93	109	125	141	157	173	189	205	221	237	253
	14	14	30	46	62	78	94	110	126	142	158	174	190	206	222	238	254
	15	15	31	47	63	79	95	111	127	143	159	175	191	207	223	239	255

↑
Beacon Zone

- MAS numbers increase with time from 0 to 255
- Columns contain 16 consecutive MAS (Allocation Zone)
- Rows contain 16 evenly spaced MAS in superframe (Coordinated MAS Set)

MAS Allocation Policy Principle #1



- Most available reservations may be made at any time. There are a variety of rules that indicate when a portion of a reservation must be moved or dropped under contention
- Example
 - On an empty channel a hard drive backup must be able to utilize the entire channel for optimal performance until there is contention

MAS Allocation Policy Principle #2



- A device must have a deterministic way to know when it may obtain MAS from another device through contention

Relinquish Requests



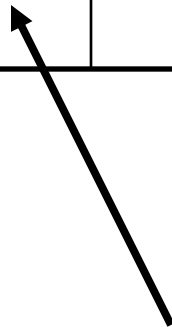
octets: 1	1	2	2	4		4
Element ID	Length (=4+4×N)	Relinquish Request Control	Target DevAddr	Allocation 1	...	Allocation N

- Request to release reserved MAS
- Allocations use same format as DRP IE
- Basic MAC mechanism to allow devices to take optimal (any) reservation on an empty channel but still have a policy structure that balances the needs of different reservation types

Unsafe Reservations – DRP Control Field



bits: b15-b13	b12	b11	b10	b9	b8-b6	b5-b3	b2-b0
Reserved	Unsafe	Conflict Tie-breaker	Owner	Reservation Status	Reason Code	Stream Index	Reservation Type



Reservations Must Be Marked Unsafe If They Are Subject To Preemption

Relinquish Requests Are Only Sent To Devices With DRP IEs Marked Unsafe



- Latency
 - Smallest application needs submitted to MAC committee were 4-5 milliseconds (game controllers)
 - Rules are designed offer availability for 4.096 millisecond latency reservations until superframe becomes fairly crowded (A row in the 2 dimensional superframe view)
- Contiguous Reservation Blocks
 - PCA has large efficiency gains up to block sizes of 4 contiguous MAS
 - Rules are designed to offer availability for reservations with contiguous block sizes of at least 4 MAS until the superframe becomes very crowded

Conclusions



- WiMedia MAC policy allows for multiple devices interact
 - The policy deal with aspects of device behavior that can adversely affect the performance and/or ability to function for other devices
- WiMedia MAC Provides the following key Personal Area Networking features
 - Mobility, Support for isochronous and asynchronous data, Decentralized PAN Operations
- WiMedia MAC Specification 1.2 expected to be completed by end of Q3 2006
 - Adds MAC support for Detect and Avoid (DAA)

Additional Information



- Join WiMedia for additional information on the MAC Specification and the workgroup
 - <http://www.wimedia.org/en/index.asp>



Acronyms

- PCA – Prioritized Contention Access
- EDCA – Enhanced Distributed Channel Access
- TDMA – Time Division Multiple Access
- CSMA – Carrier Sense Multiple Access
- DRP – Distributed Reservation Protocol
- BP – Beacon Period
- MAS – Media Access Slot
- TIM – Traffic Indication Map
- IE – Informational Element



Developers Conference 2006

Taipei, Taiwan



Backup

Purpose of Beacons

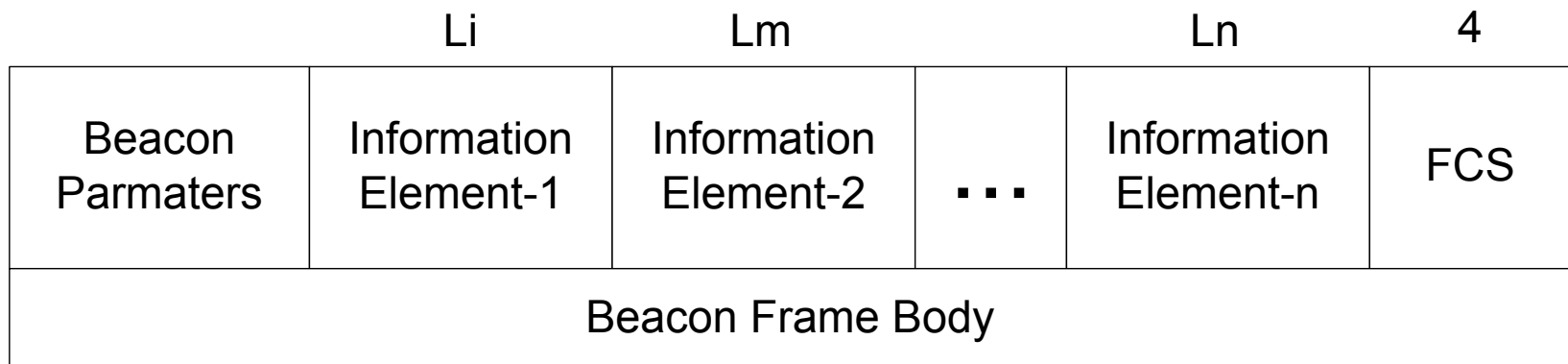


- WiMedia Device Discovery
- Superframe Time synchronization
- Creating, Sharing and Honoring Reservations
- Traffic Indications Map (TIM) Information
- Interference Mitigation

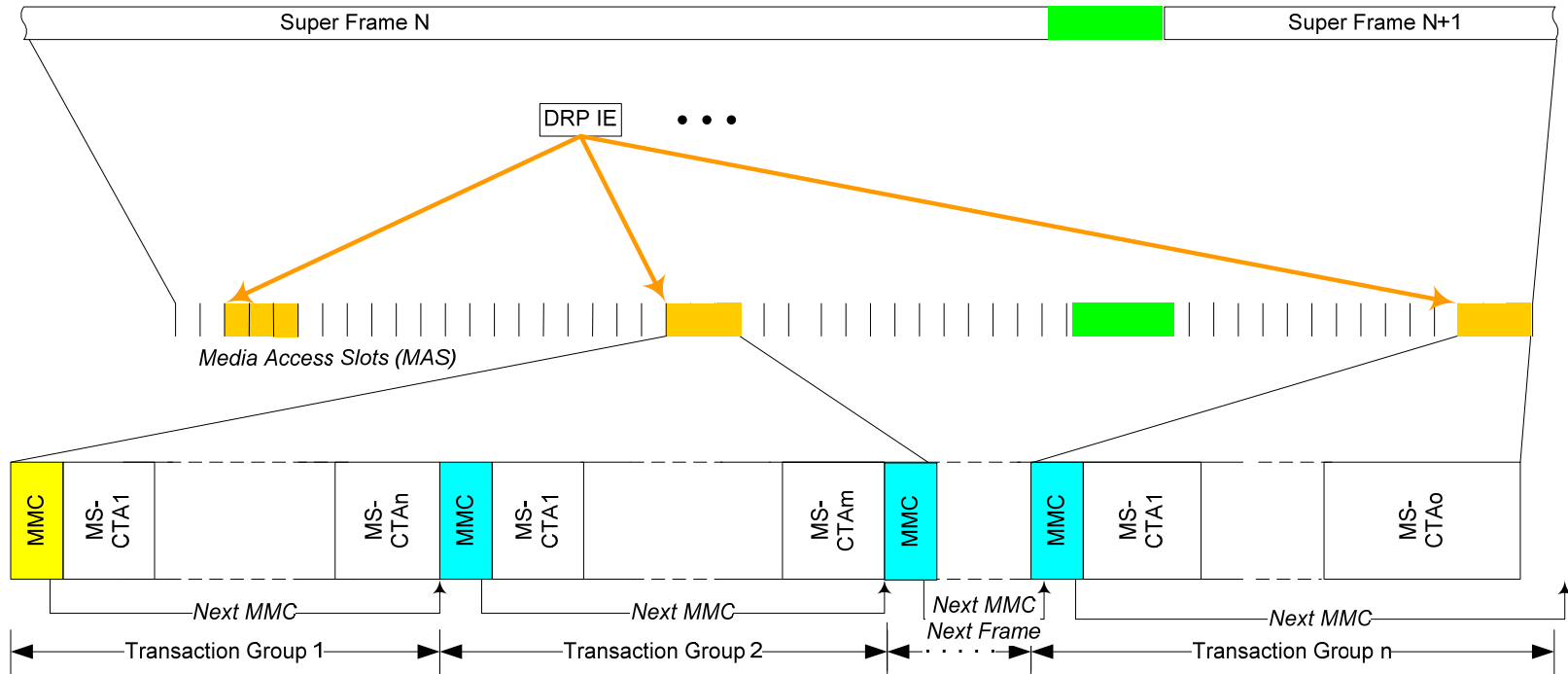
IE in Beacon



- Distributed Reservation Protocol IE
- Beaconsing Period Occupancy Information Element
- Traffic Indication Map (TIM) IE



MAC Synchronization and MMC



- MAC Synchronization must be done at end of the superframe
- In the Last MMC, the Next MMC field must be adjusted

Beaconing Period Occupancy Information Element (BPOIE)



octets: 1	1	1	K	2	...	2
Element ID	Length $=1+K+2*N$	BP Length	Beacon Slot Bitmap	DevAddr 1	...	DevAddr N

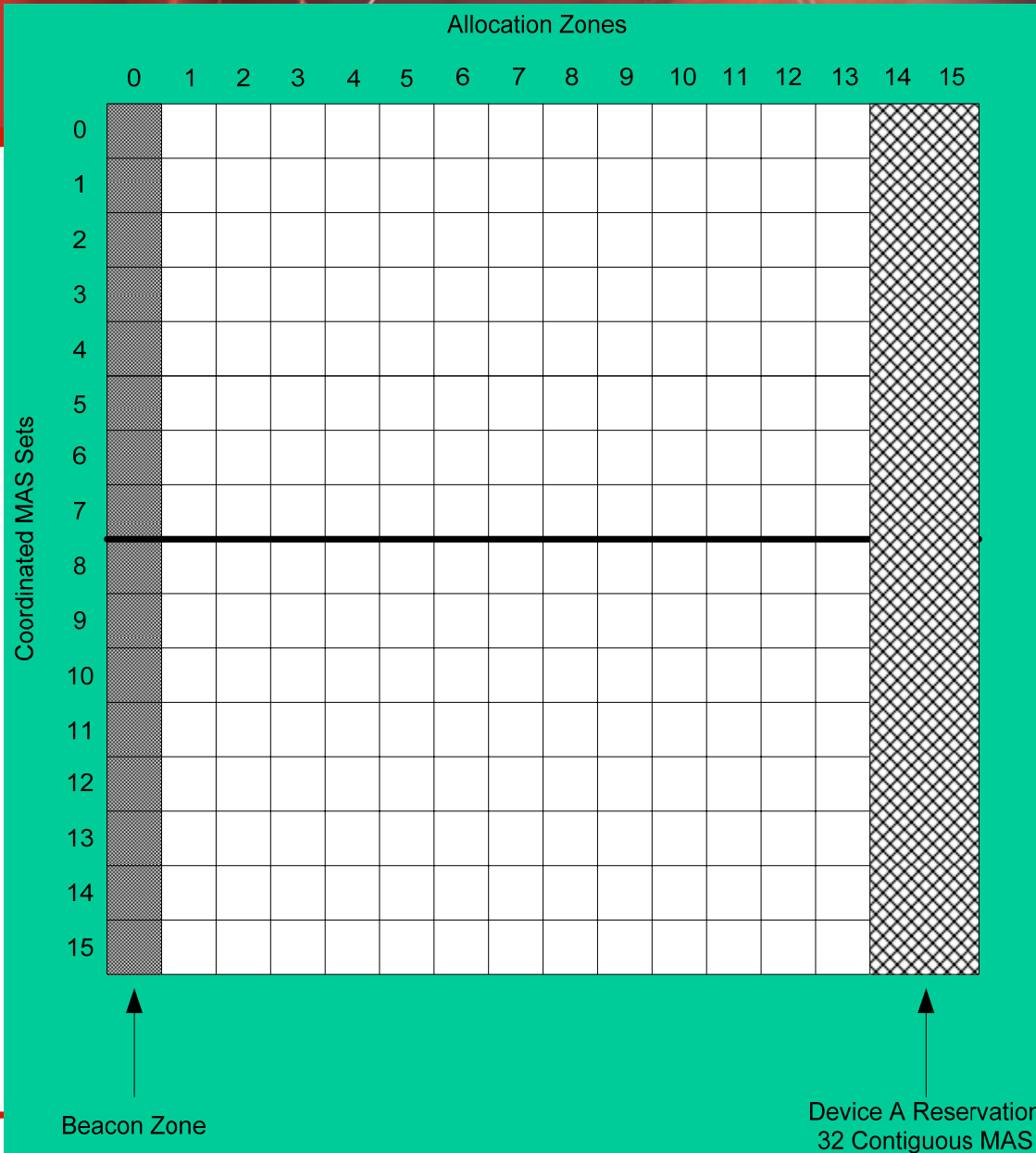
- BPOIE allows other devices to determine the set of neighbor for a device
- The host can use this information to determine if the device is required to perform directed beaconing

Medium Access Methods



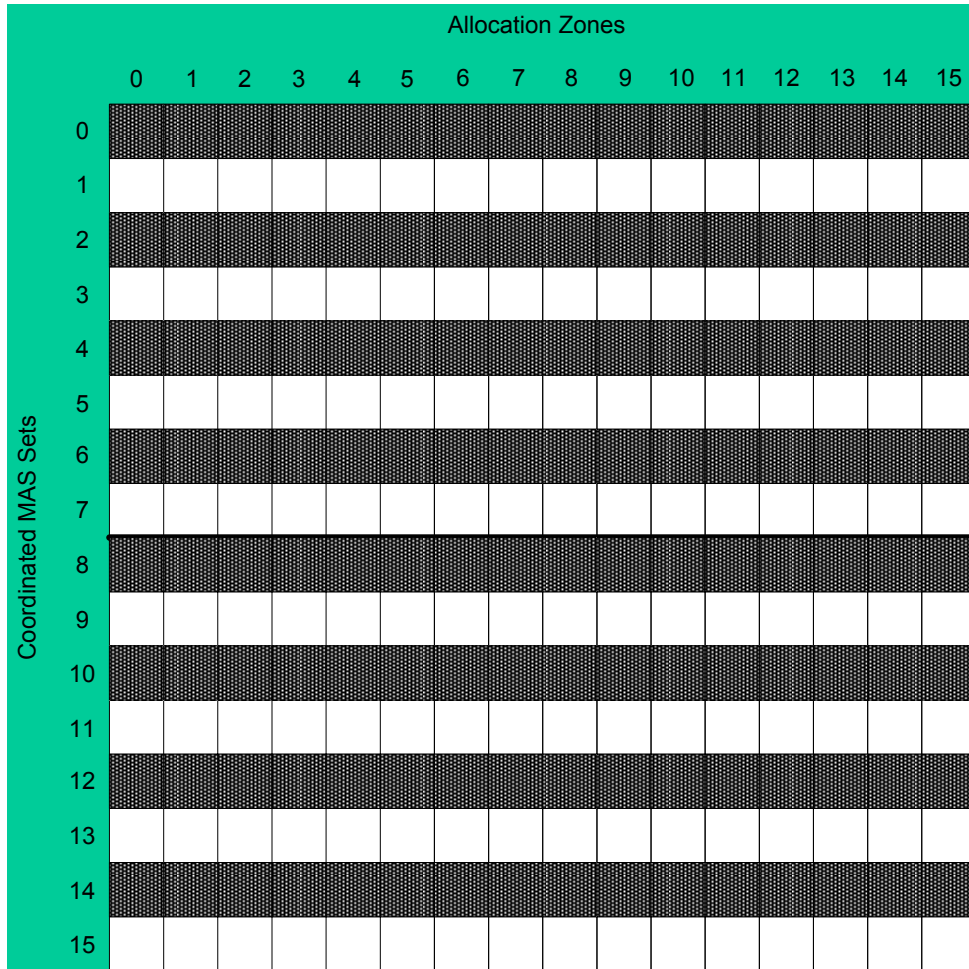
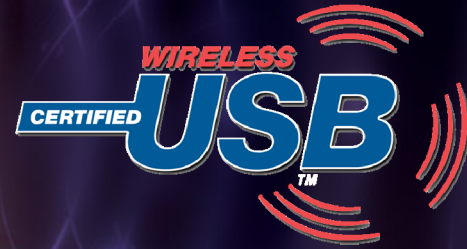
- Distributed Reservation Period (DRP)
 - Beacon Period (BP) Reservations
 - Hard Reservations
 - Private Reservations
 - Soft Reservations
 - PCA Reservations
- Prioritized Contention Access (PCA)

Low Latency Devices



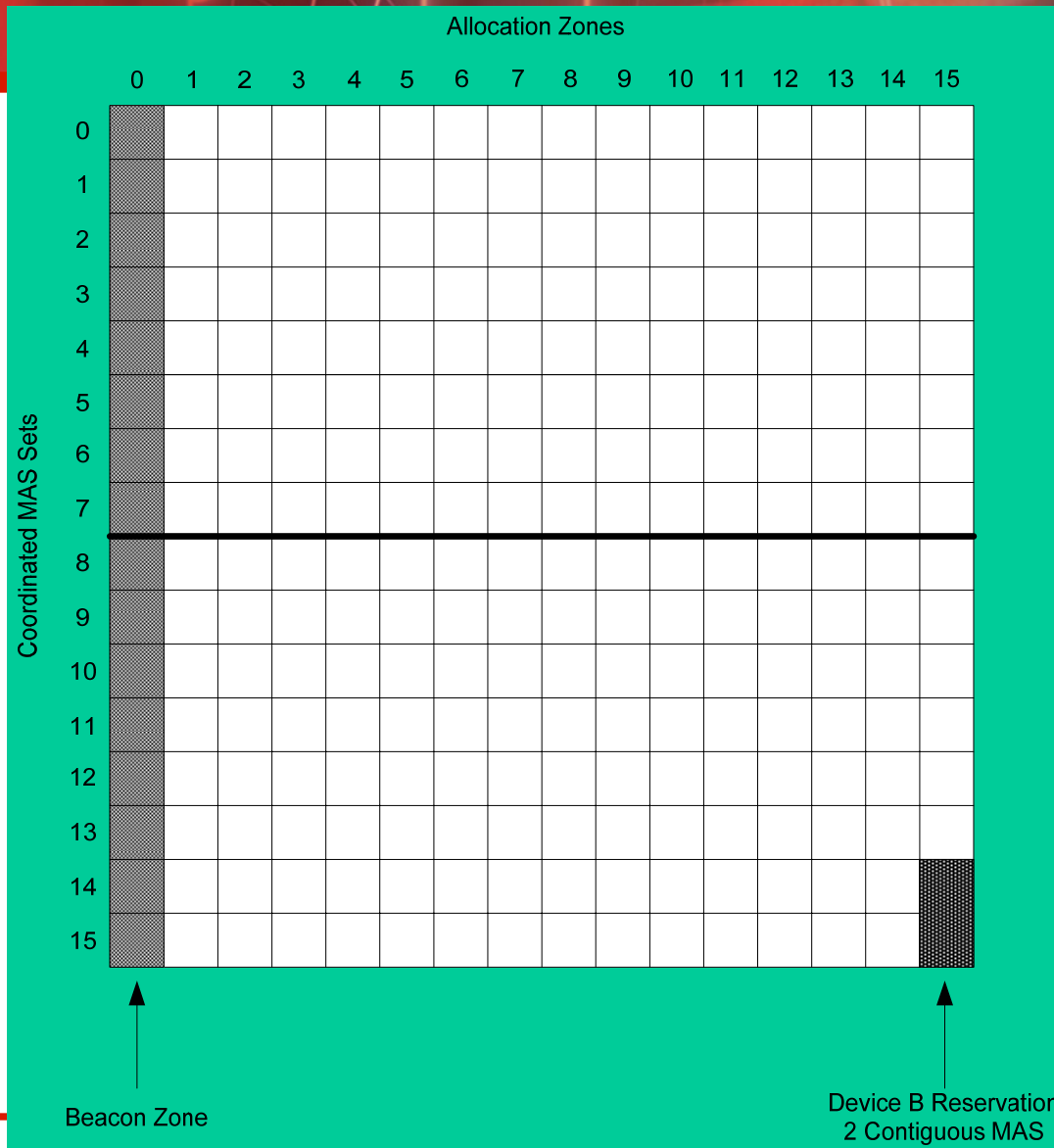
- Some power conscious devices prefer large contiguous reservations
- Large contiguous reservations can make a sparsely occupied channel unusable for devices with small service interval requirements

Power Conscious Devices



- Some devices prefer large contiguous reservation blocks for power or transfer efficiency reasons
- Small service interval reservations limit the availability of contiguous blocks of MAS for reservations

Power Conscious Devices



- Device B is power conscious and prefers to reserve the last 2 contiguous MAS in superframe
- Device B takes 2 MAS to power on from deep sleep state
- Other positions in superframe require powering on/off twice
- Power conscious devices must be able to choose the optimal reservation if there is no contention

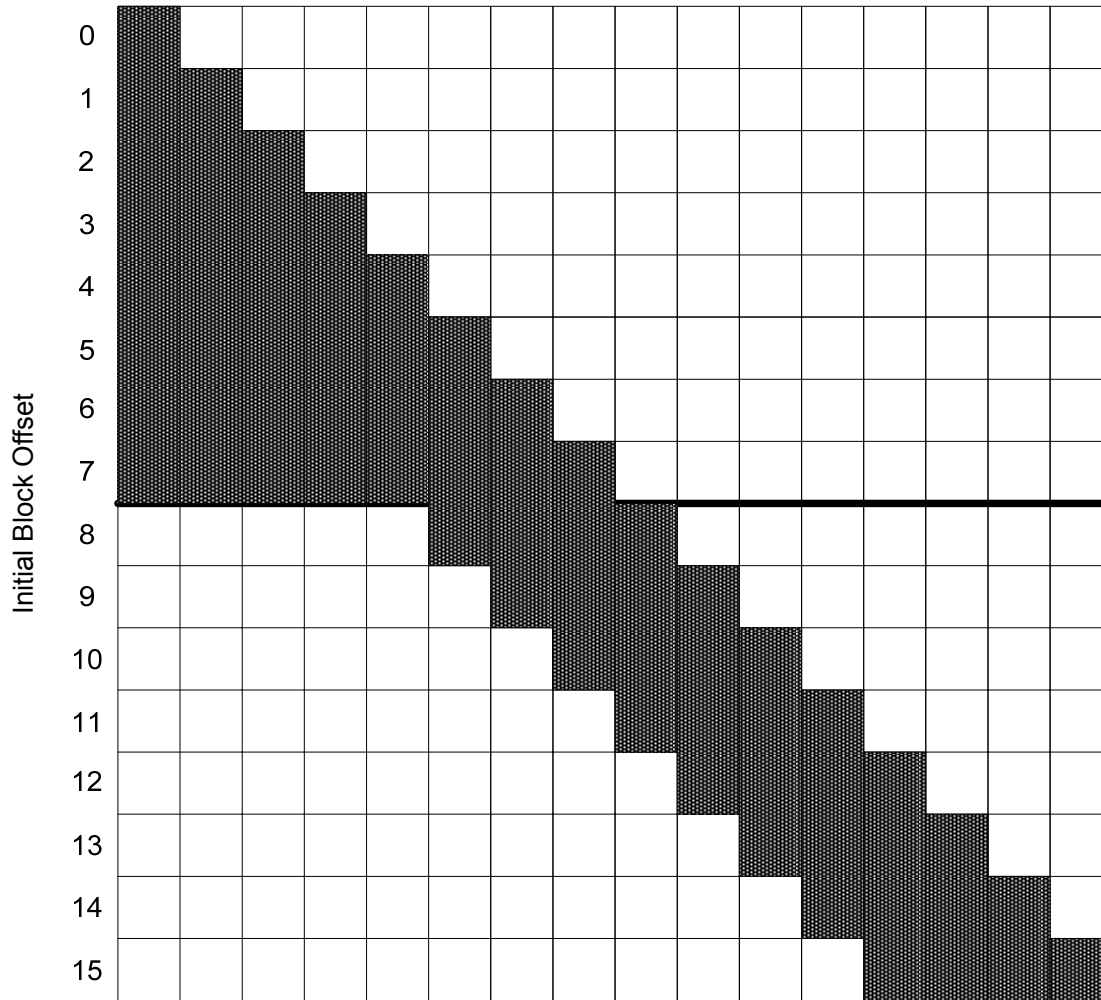
Reservation Components



- **Row Component** – A portion of a reservation that includes an equal number of MASs at the same offset(s) within every zone, optionally excluding zone zero
- **Column Component** – The portion of a reservation that is not a row component



Limits on Size of Blocks (Y) in Column Components



- If block fits entirely in top half of superframe block size is not further constrained
- Otherwise, block size is limited to 4
- All policies generally favor Column components in the top half of the superframe and row components in the bottom half

Safe vs. Unsafe Reservations



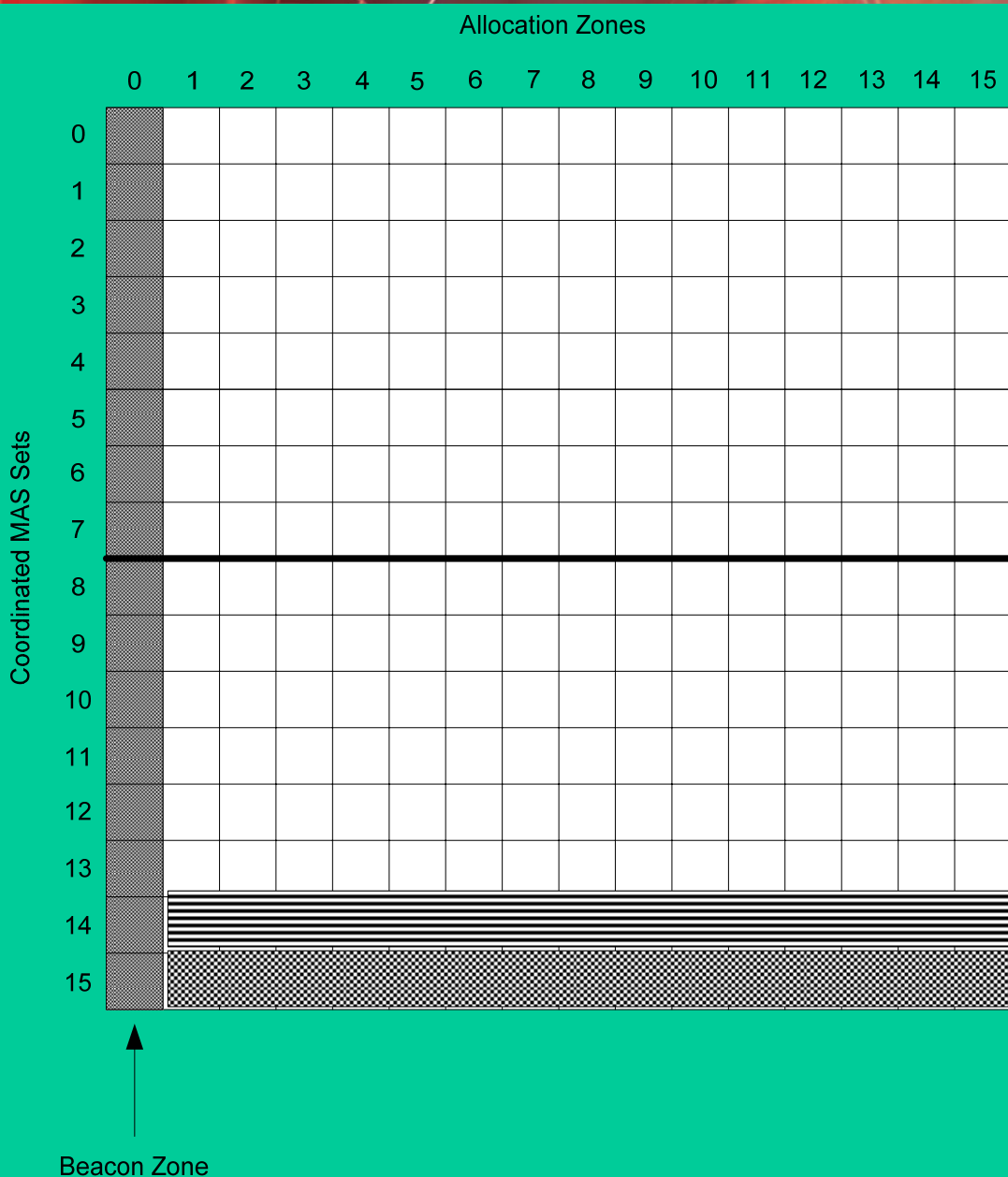
- A device shall not make reservations with more than 112 MAS in DRP IEs that are marked safe
- A device shall not mark more than Y contiguous MAS in a column component reservation block safe
- Devices with DRP IEs marked unsafe must give up requested MAS or become safe if they receive a relinquish request

Column Component Location Policy Summary



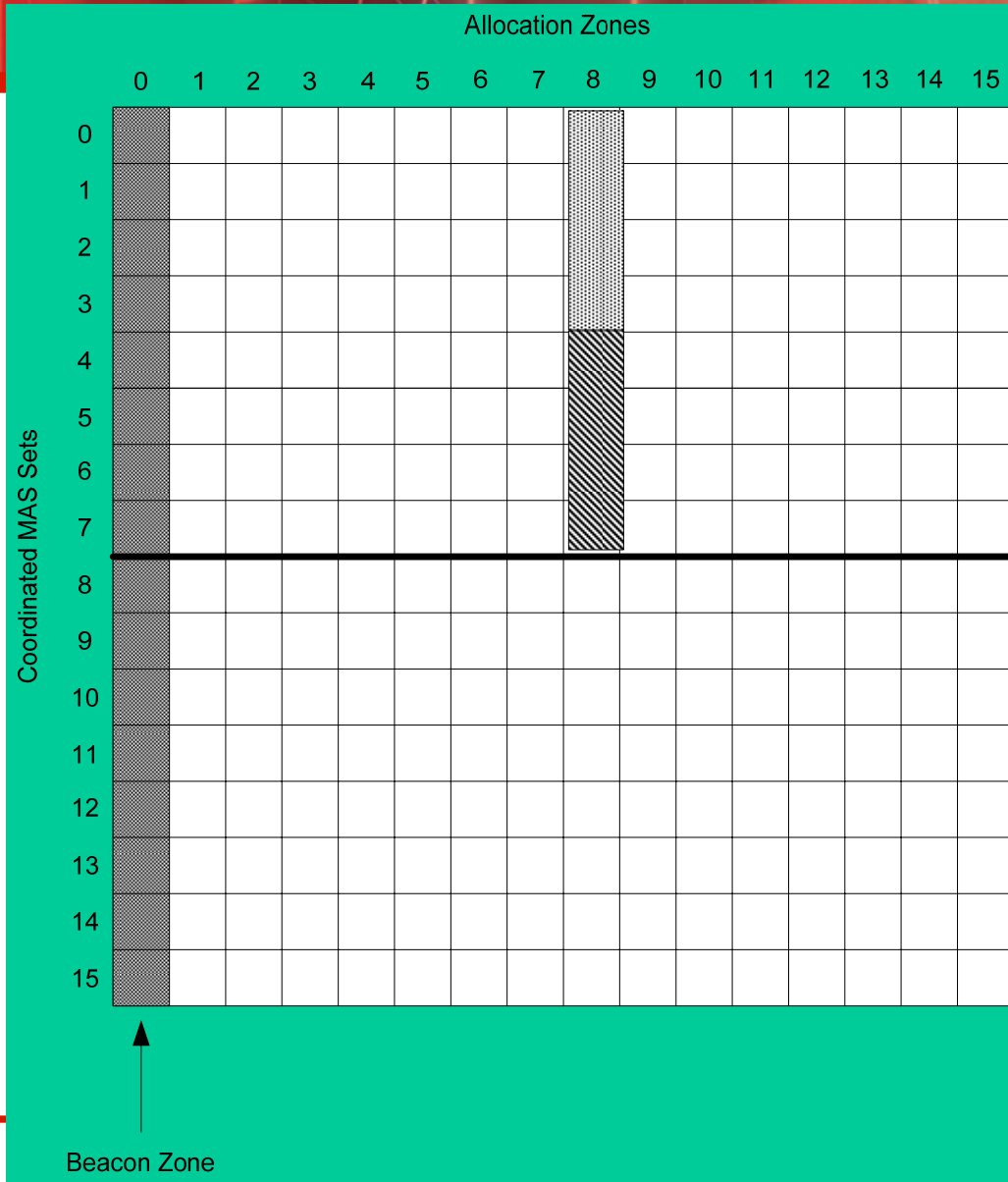
- If column component can fit entirely in top half of superframe it must and
 - Minimize highest used zone index
- Else
 - Column component must minimize how far down in the superframe it is located
 - Minimizing highest used zone index is a tiebreaker

Rebalancing – Row Components



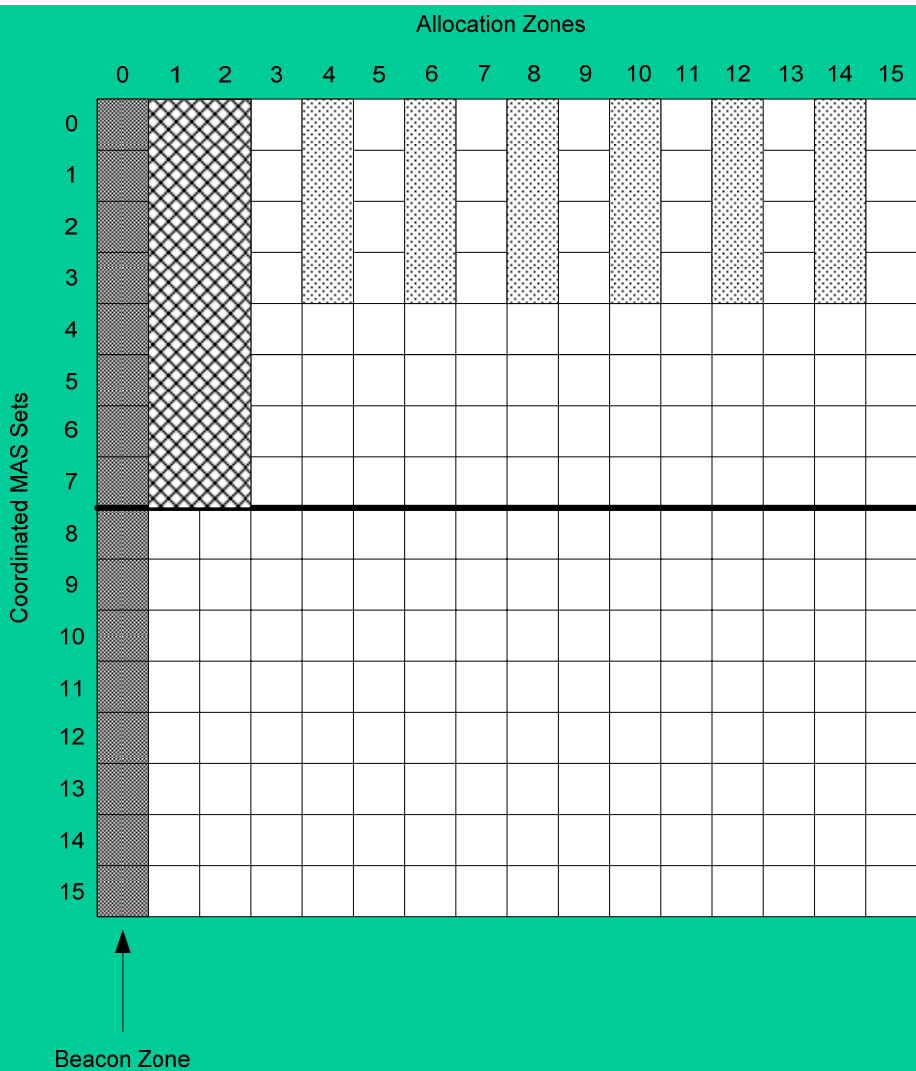
- A row component must move lower in the superframe if possible

Rebalancing – Column Components



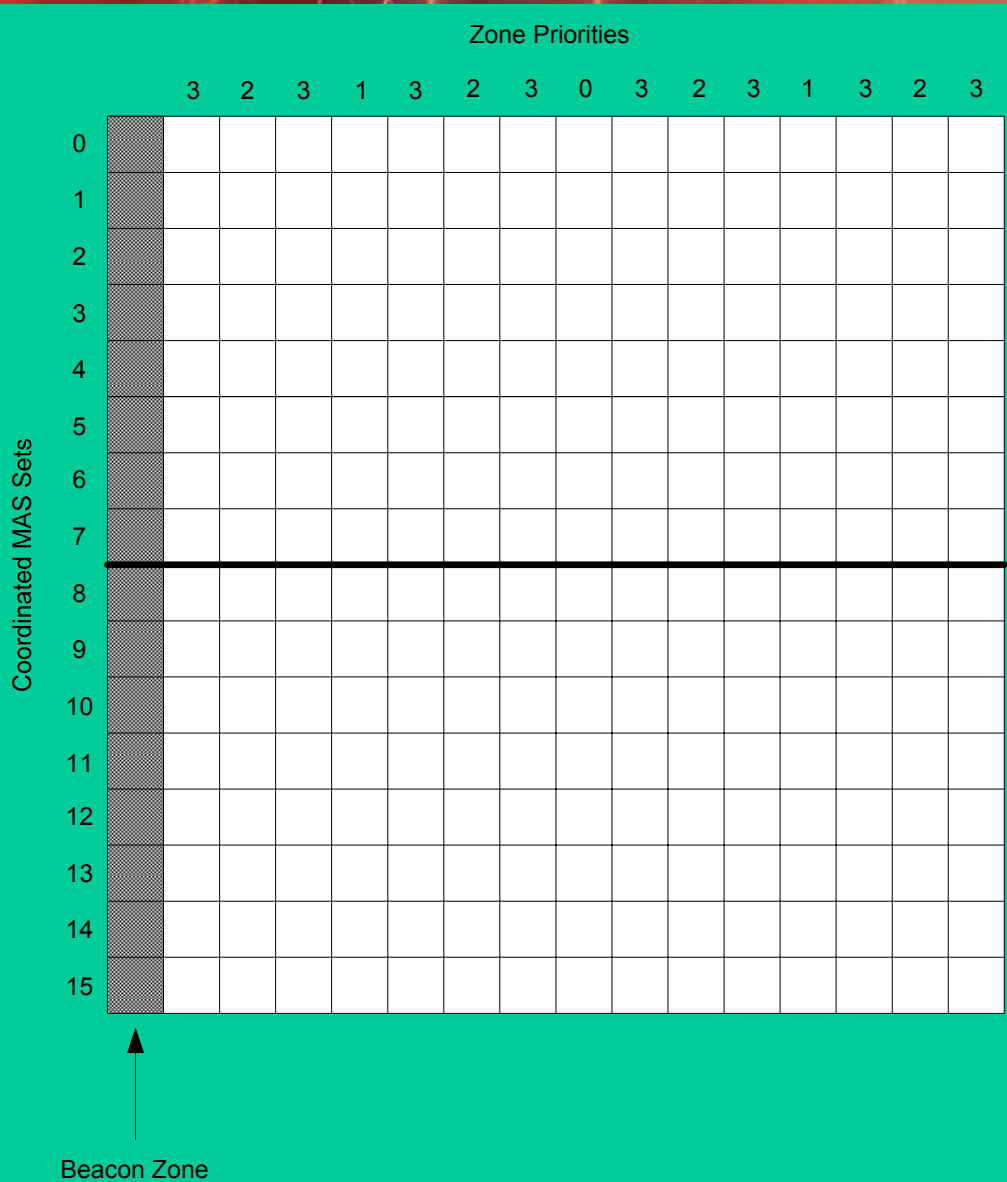
- A block in an column component most move up in its zone if possible

Column Component Service Intervals



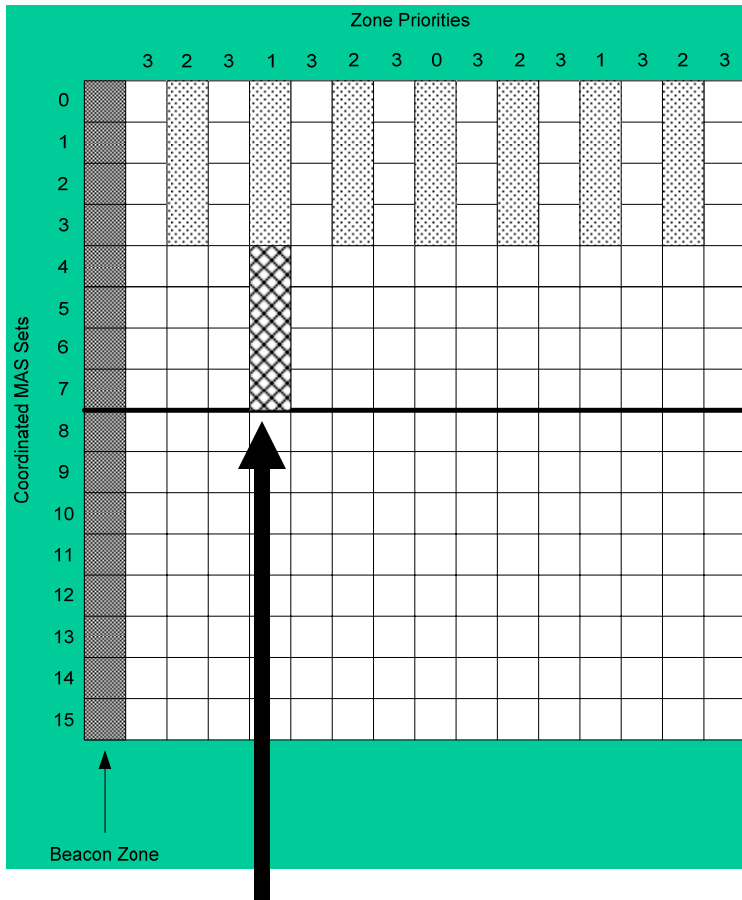
- Though applications using column reservations prefer contiguous MAS they may also care to some extent about service interval
- A single column component reservation may prevent lower service intervals for all other reservations

Zone Priorities

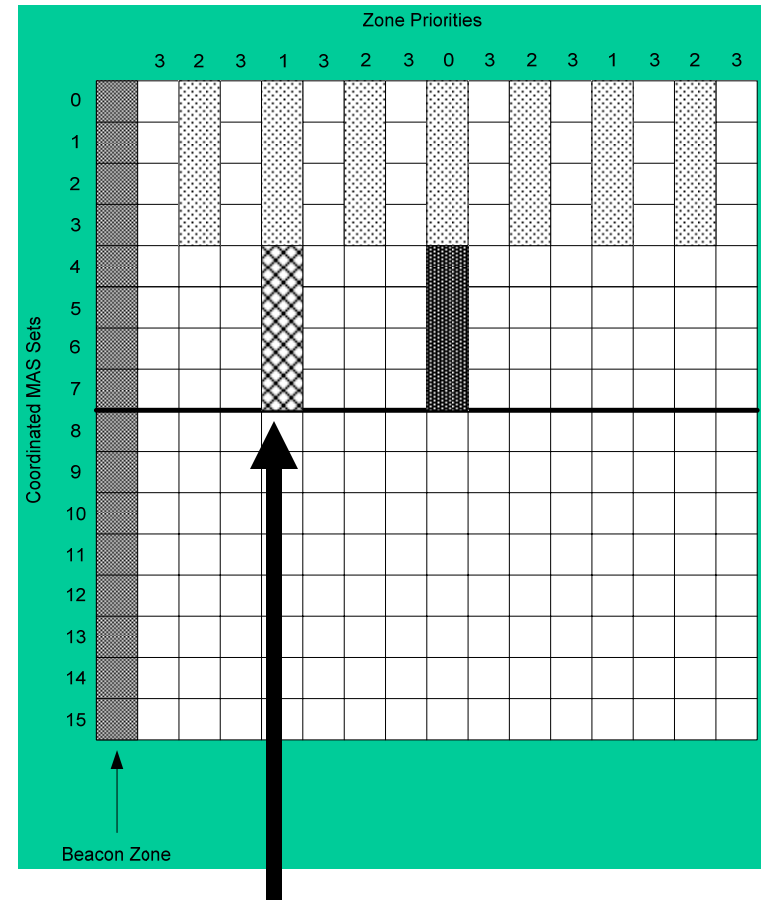


- Zone columns have numbers from 0 to 3
- Contiguous reservations in each column are treated individually
- If the same size contiguous reservation is available in a lower priority column the column must be moved if this can be done without breaking service interval requirements for the column component

Unrestricted Zone Priority – Example 1

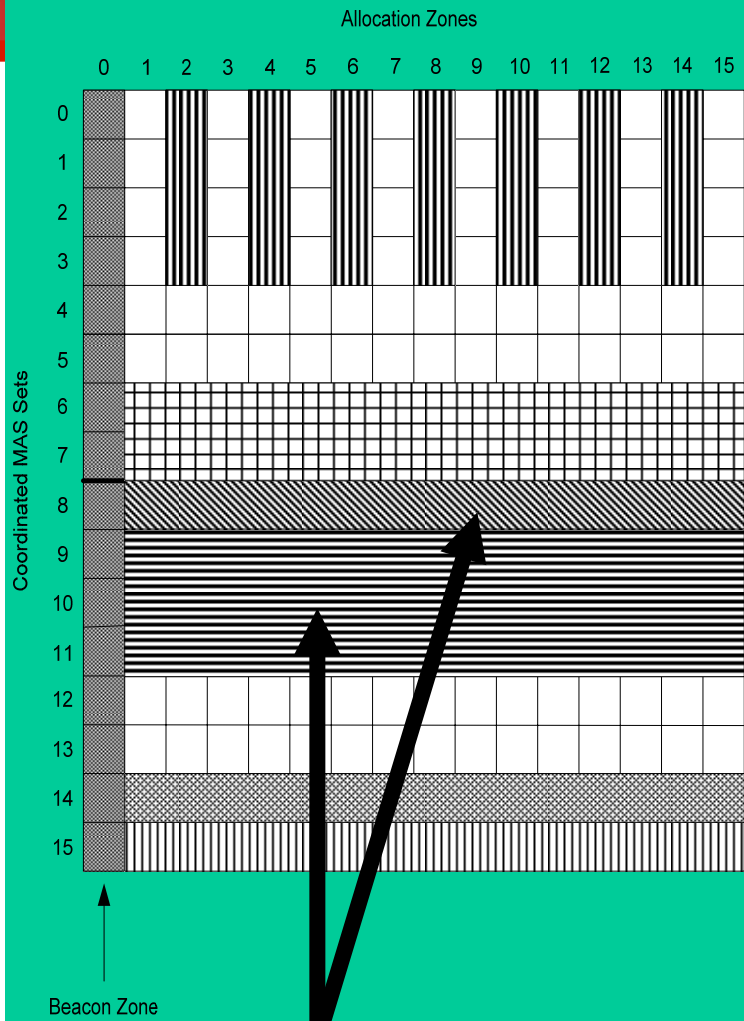


Not Allowed

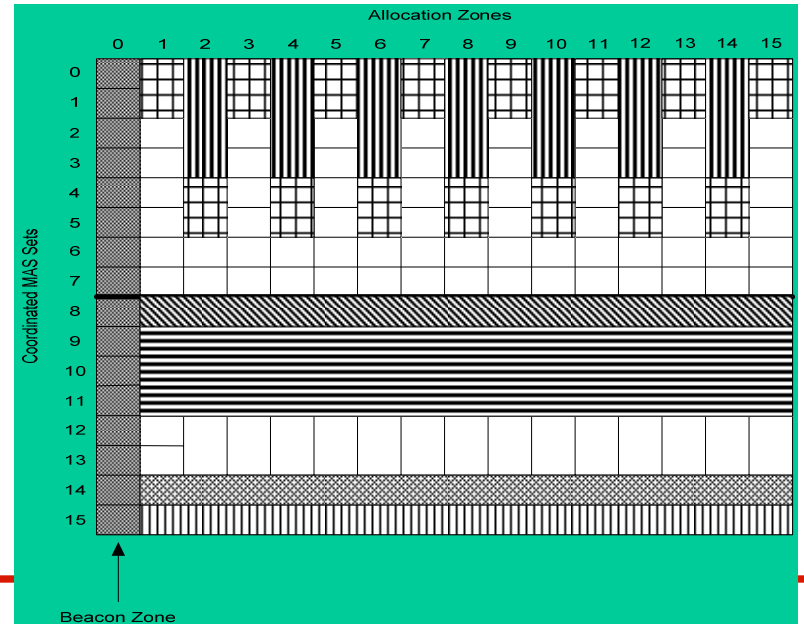
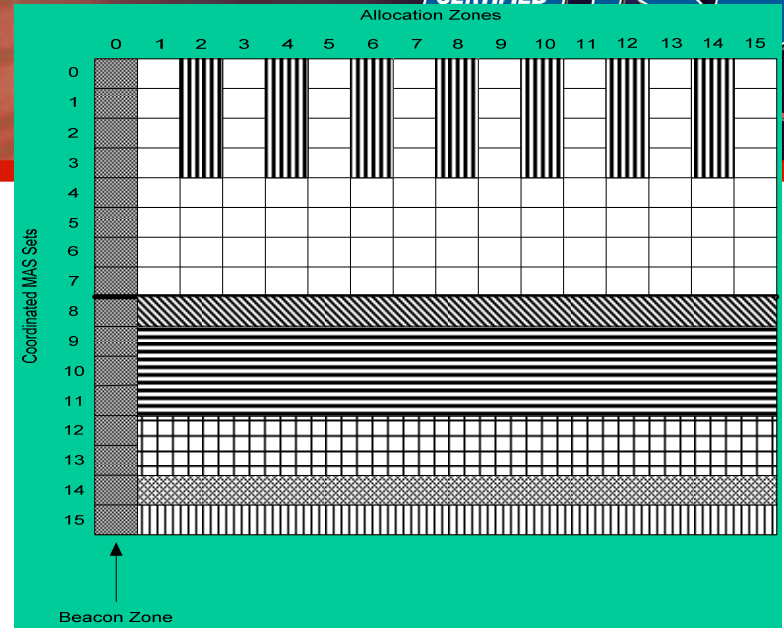
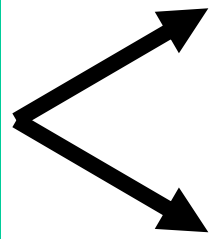


Allowed

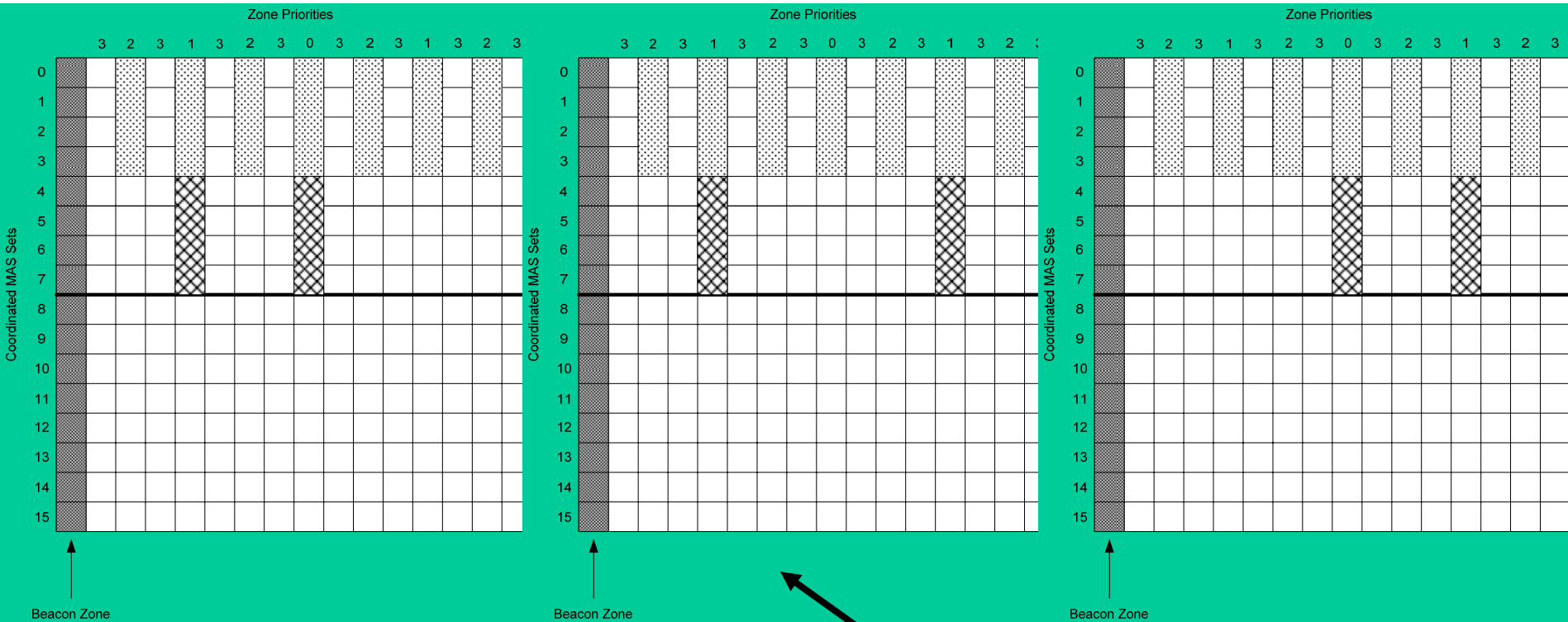
Rebalancing – Row Components



Not Movable



Row Components $K = 2$ Allowed Examples



Only Allowed If Service Interval Requires