FIXED ASSIGNMENT VS. RANDOM ACCESS MAC PROTOCOLS FOR MULTIMEDIA IOT APPLICATIONS

However, before getting into the comparisons... what are MAC protocols and how are the relevant in IoT?

MAC STANDS FOR...

Medium Access Control, which are generally a set of protocols that enable **multiple users** to share **finite amount of frequency and time resources**

TYPES OF MAC

There are generally two categories of MAC protocols:

1. Fixed Assignment
2. Random Access

MAC IN IOT APPLICATIONS

IoT infrastructure uses multiple wireless networks and standards in order to transmit information between various levels in within its networking architecture. Given that wireless networks consist of multiple terminals requiring to communicate at the same time, MAC is used to allow **multiple terminals** to transmit over the wireless channel and share **the finite resources and capacity of the wireless channel**

FIXED ASSIGNMENT

In fixed assignment MAC protocols, each node is allocated a predetermined fixed amount of channel resources. Each node will use its allocated resources exclusively without competing with other nodes

Some examples of Fixed Assignment protocols:

1. Time Division Multiple Access
Channel Resource - Time
Overview - each node is given a specific time to transfer data

2. Frequency Division Multiple Access
Channel Resource - Frequency Band
Overview - each node is allocated a specific frequency band to transfer data

3. Code Division Multiple Access
Channel Resource - CDMA Codes
Overview - each node is allocated a specific CDMA code to transfer data, allowing node to use entire band of frequencies without limit

4. Space Division Multiple Access
Channel Resource - Coverage Space
Overview - each node is allocated a space sector which can further use TDMA/FDMA to divide time frequency resources amongst users

RANDOM ACCESS

In random access MAC protocols, each node has equal priority and superiority to access and use the entire of the channel resources. There is no segmentation and allocation of channel resources. Thus, the channel is shared by every node in the network.

Some examples of Random Access protocols:

1. ALOHA
Overview - each node will transmit data whenever there is an available frame
Variation 1, Pure Aloha - transmit whenever there is an available frame
Variation 2, Slotted Aloha - divide channel into slots, only transmit at the start of every slot
Problem - high rates of collision

2. CSMA
Overview - each node will listen to channel before transmitting a packet (listen-before-talk protocol)
Variation 1, 1-Persistent-CSMA - listens continuously till channel is idle
Variation 2, Non-Persistent-CSMA - listens and if channel is busy, waits a random amount of time before listening again
Variation 3, P-Persistent-CSMA - listens and if channel is idle, transmit data with a probability of p. Waits for next slot with probability of (1 - p).
Problem - lesser but collisions still present due to propagation delay

Evaluation of Fixed Assignment protocols and how it may be useful for multimedia data transmission by IoT devices:

1. TDMA

+ Uses less resources (narrowband filters)
+ Energy & power efficient
+ High data transmission rates
- Time delays to handle different users
- Requires signal processing
- Has high overheads for synchronisation

2. FDMA

+ Less overhead as synchronisation not necessary
+ Nodes can transmit information without time delay
+ The complexity of the system is low
- Inflexible allocation of frequency allocated
- Limitations in bandwidth & transmission
- Interference among different frequencies

3. CDMA
+ Increment proficiency as it can serve more clients.
+ Does not need any synchronisation.
+ Can take many clients in a similar data transmission.
- Close far issue
- Greater expense because of more complexed technologies used
- Reduce capacity because gradual transfer increases the use of radio resources

4. SDMA
+ Low battery consumption
+ High bandwidth or data rate
+ Usually combined with other multiplexing techniques to better utilise the individual physical channel
- High number of switches used
- Very computationally expensive with complicated design
- High possibility of insertion losses since each input must have the capability to be split to any output.

Evaluation of Random Access protocols and how it may be useful for multimedia data transmission by IoT devices:

1. Pure ALOHA

+ Any station can transmit the data at any time
+ The time is continuous and not globally synchronised.
+ Simple Implementation
- Higher vulnerability time in which collision may occur
- Lower probability of successful transmission of data packet
- Lower maximum efficiency of 18.4%

2. Slotted ALOHA

+ Lower vulnerability time in which collision may occur
+ Higher probability of successful transmission of data packet
+ Higher maximum efficiency of 36.8%
- Any station can only transmit the data at the beginning of any time slot.
- The time is discrete and globally synchronised.

3. CSMA

+ Inexpensive. and fast.
+ Very simple to implement.
+ Listen-before-talk protocol reduces rates of collision
- Not scalable due to broadcasting.
- Long waiting time.
- High power consumption.
- May lack in network availability and resilience

References:

Fixed assignment schemes. BrainKart. (n.d.). Retrieved April 14, 2022, from https://www.brainkart.com/article/Fixed-Assignment-Schemes_9879/

Random access. BrainKart. (n.d.). Retrieved April 14, 2022, from https://www.brainkart.com/article/Random-Access_13450/

CHARACTERISTICS & NEEDS FOR TRANSMITTING DATA BY MULTIMEDIA IOT DEVICES

- High Quality, High-Definition for graphical data (e.g. Image, Video)

- High-Speed Transmission

- Optimal Peak-To-Average Ratios

- Support for busty data traffic

- High Quality-of-Service (QoS) Requirements (e.g. delay, jitter)

- Efficient usage of network resources

FIXED ASSIGNMENT

For uplink transmissions or peer-to-peer transmissions, fixed assignment can ensure QoS with low resource utilisation

For transmission of bursty traffic with high peak-to-average ratio, fixed assignment leads to significant wastage of resources

RANDOM ACCESS

Performance of random access protocols will degrade when transmitting multimedia data when networks are congested and collisions occur frequently

For transmission of bursty traffic , random access protocols are flexible and efficient in sharing resources, gaining certain levels of multiplexing benefits

References:

Zhang, R., Ruby, R., Pan, J., Cai, L., & Shen, X. (2010). A hybrid reservation/contention-based MAC for video streaming over Wireless Networks. IEEE Journal on Selected Areas in Communications, 28(3), 389–398. https://doi.org/10.1109/jsac.2010.100410