

ADAPTIVE RACH CONGESTION MANAGEMENT TO SUPPORT M₂M COMMUNICATION IN 4G LTE NETWORKS

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Outline



- Introduction to IoT
- Introduction to M2M
- Congestion Problem
- Related Work
- Proposed Work
- Simulation Setup
- Performance Results
- Conclusion and Future Work

Introduction to IoT

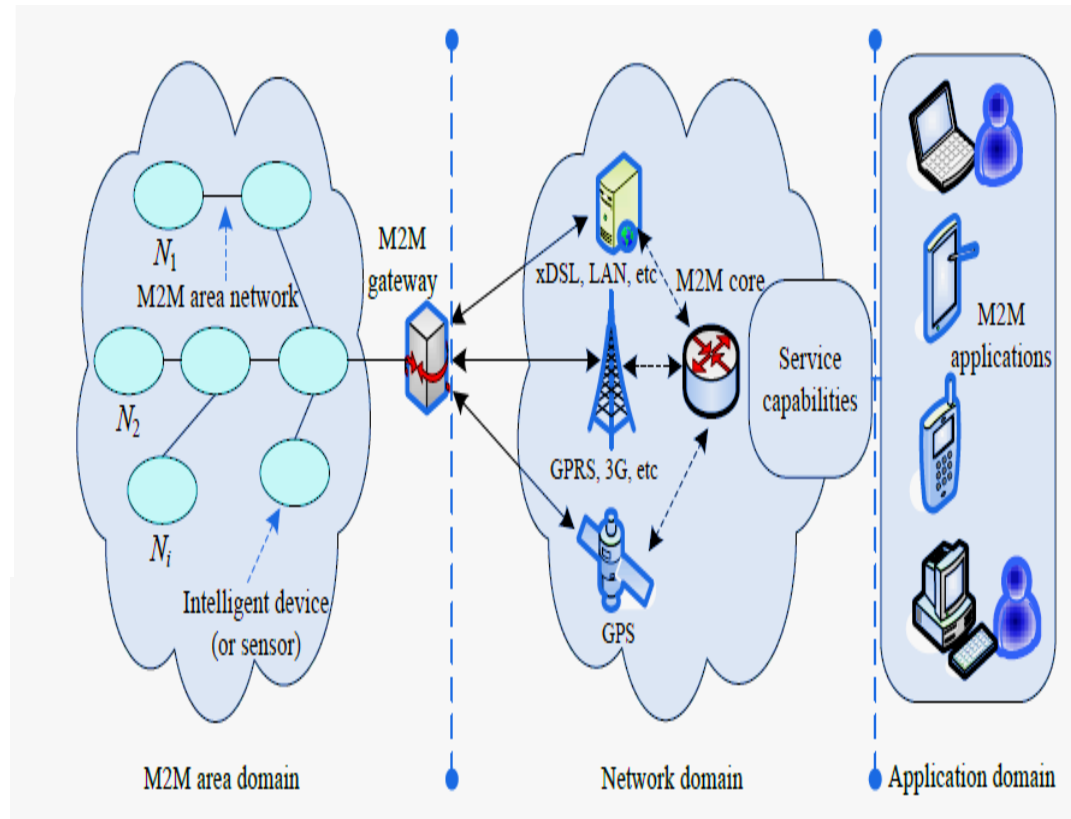
- Internet connects all people, so it is called “the Internet of People”
- IoT connects all things, so it is called “the Internet of Things”



Introduction to M2M

M2M Communication

- M2M covers the networking part of IoT
- M2M Device (Sensors, Meters)
- Communication Network (Cellular Network, Wi-Fi etc)
- Application (Software Program)
- Types of M2M Communications
 - Capillary M2M
 - Cellular M2M



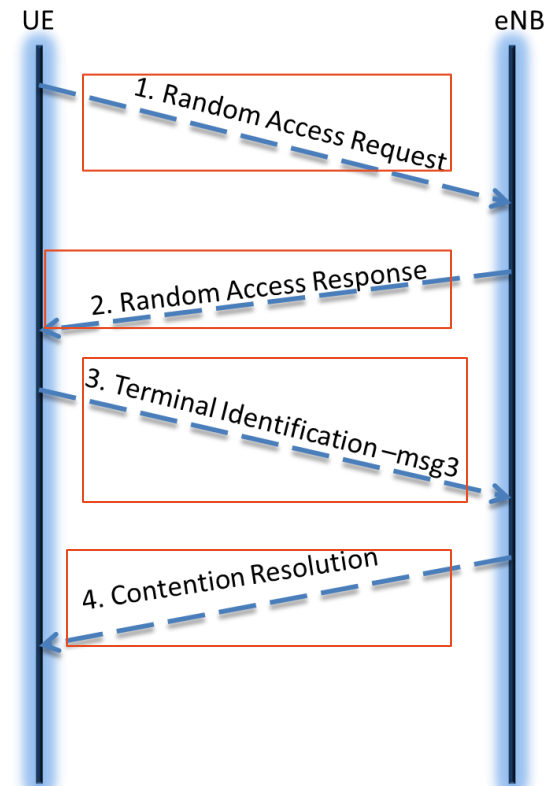
Issues in Cellular M2M



- **Scheduling Issue:**
 - Bandwidth is limited
 - Cellular Networks are designed for H2H
 - Large number of M2M devices involved
- **Signaling Congestion Issue:**
 - Signaling Overhead due to large number of M2M devices
 - Contention due to large number of M2M devices try to do RACH procedure simultaneously

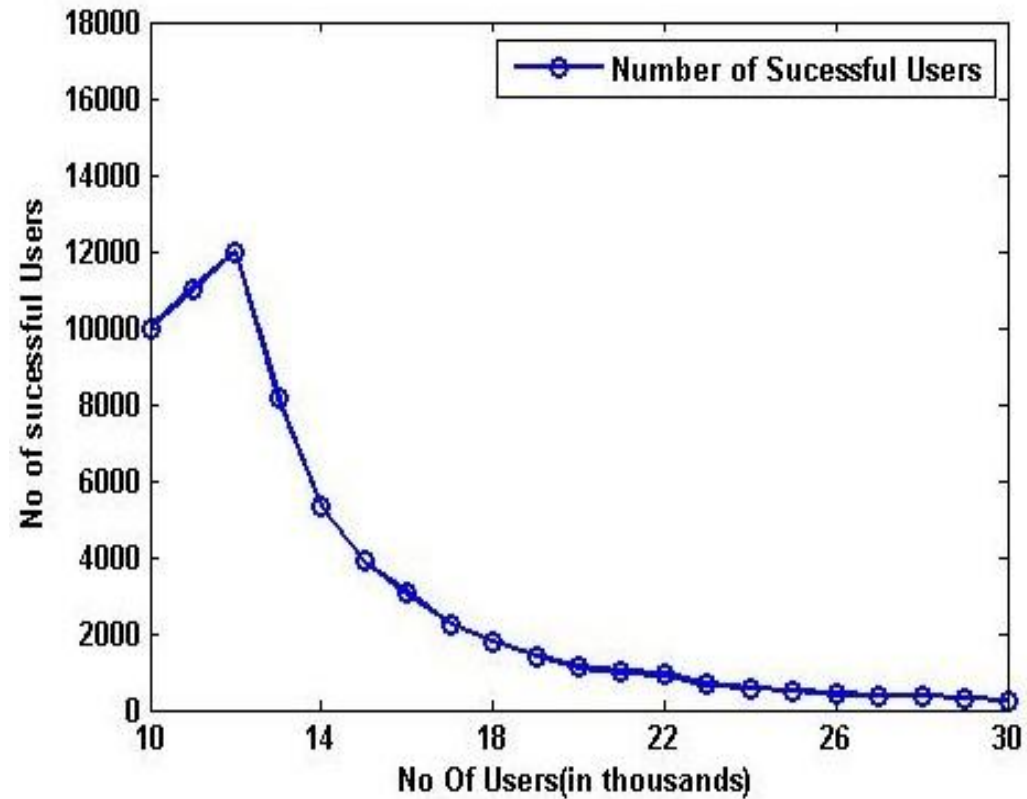
RACH procedure

- UE sends a random access preamble in step 1.
- In step 2, eNB sends a random access response which contains backoff information or scheduling grant.
- UE sends its C-RNTI or identifying information in step 3.
- eNB acknowledges the information in step 4.



Motivation

- Success rate decreases as number of M2M devices increase



Push based schemes:

- **p -persistent approach:** device will send preamble with probability p . It is suitable for medium congestion.
- **BackOff Indicator Adjustment:** M2M devices will have a larger backoff than UEs. It is suitable for low congestion.

Access Barring Methods:

- **Access Class Barring:** Different classes of devices are barred. It is a legacy method which is suitable when congestion is high.
- **Extended Access Class Barring (EAB):** devices configured as low priority are barred. Useful only when there is extreme congestion.

Pull Based Solutions:

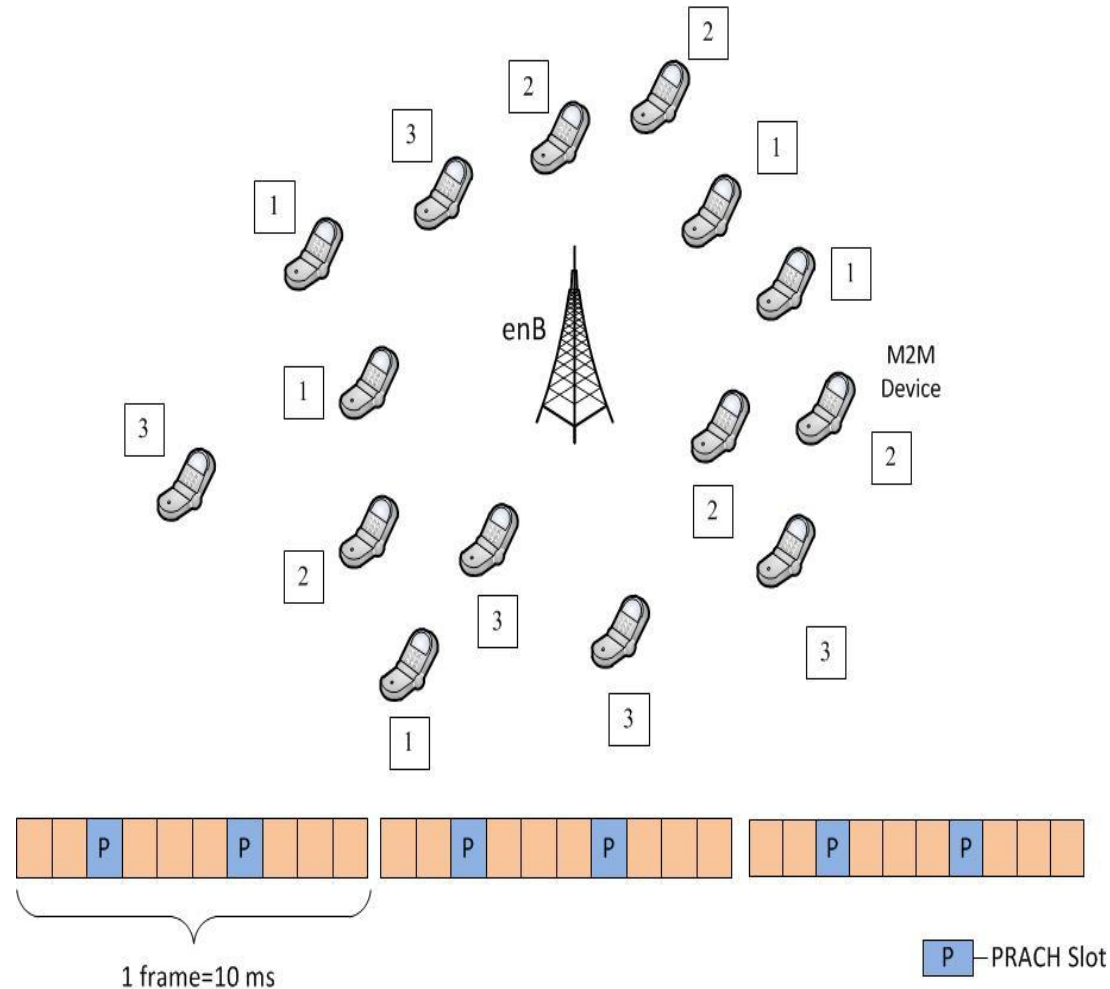
- **Contention free RACH:** device will access the network using contention free preamble. It is useful only for special cases like handovers.

Slotted Access:

- Each device sends the preamble in a particular slot only.
- In case of very high congestion this method does not perform well.

Proposed Work: Numbering Scheme

- Need for a dynamic congestion handling method
- eNodeB assigns a number to M2M device when it connects to eNodeB. It is termed as Numbering Scheme (NS).
- M2M device waits that many slots before trying to access the network in the next attempt, thereby spreading the access



NS performance

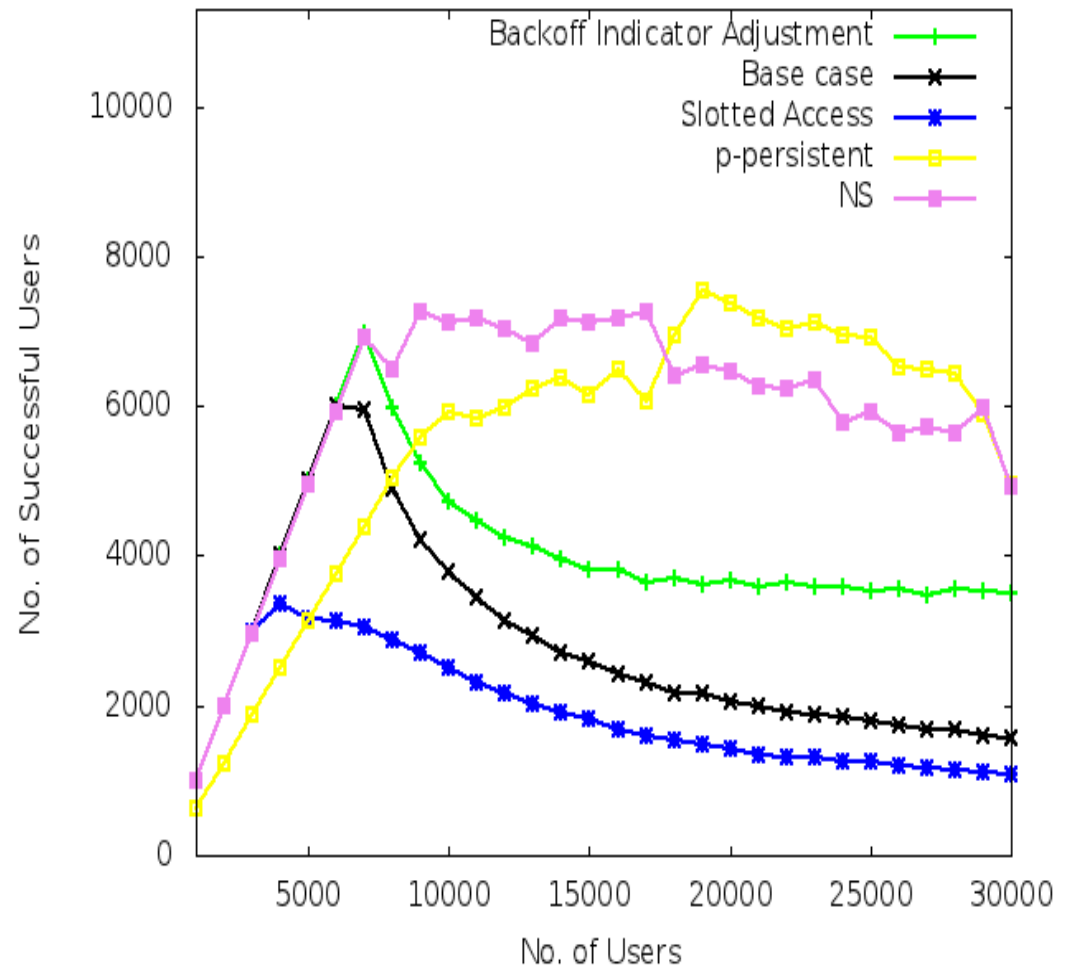
- Scenario 1: Low congestion
- Scenario 2: Moderate congestion
- Scenario 3: Extreme Congestion

- NS performs best for low congestion

- p -persistent performs best for moderate congestion

- Still need an approach which performs best in all congestion scenario

- We propose an Adaptive RACH congestion management function (ARC) to address this issue



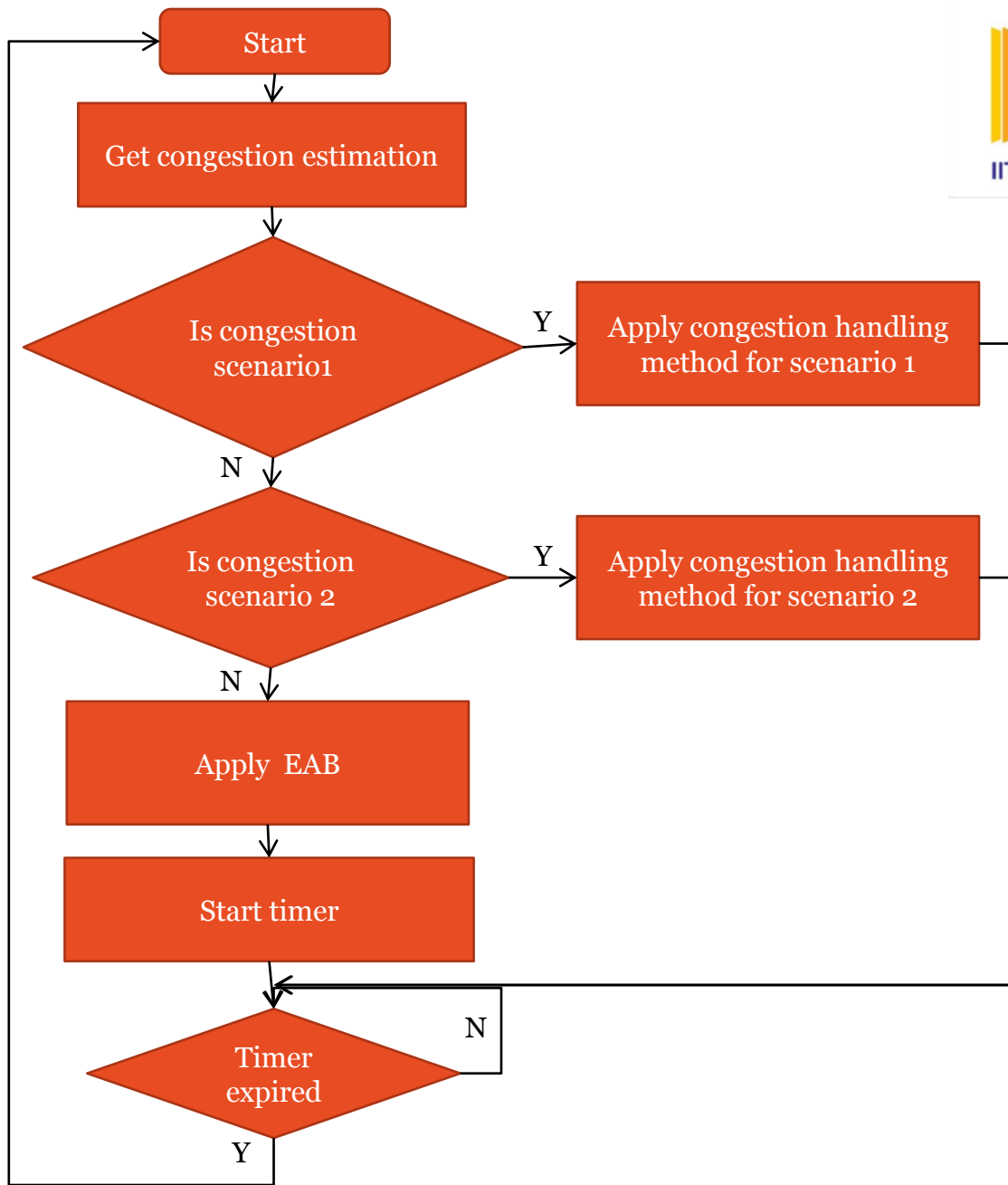
Proposed Work: ARC Function



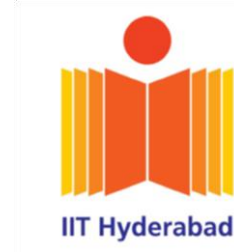
- Estimation of congestion in the network by calculating average number of backoff done by a M2M device before connecting to the network.
- λ_1 is threshold for low to medium congestion
- λ_2 is threshold for medium to high congestion
- NS for scenario 1
- p -persistent for scenario 2
- *EAB* for scenario 3

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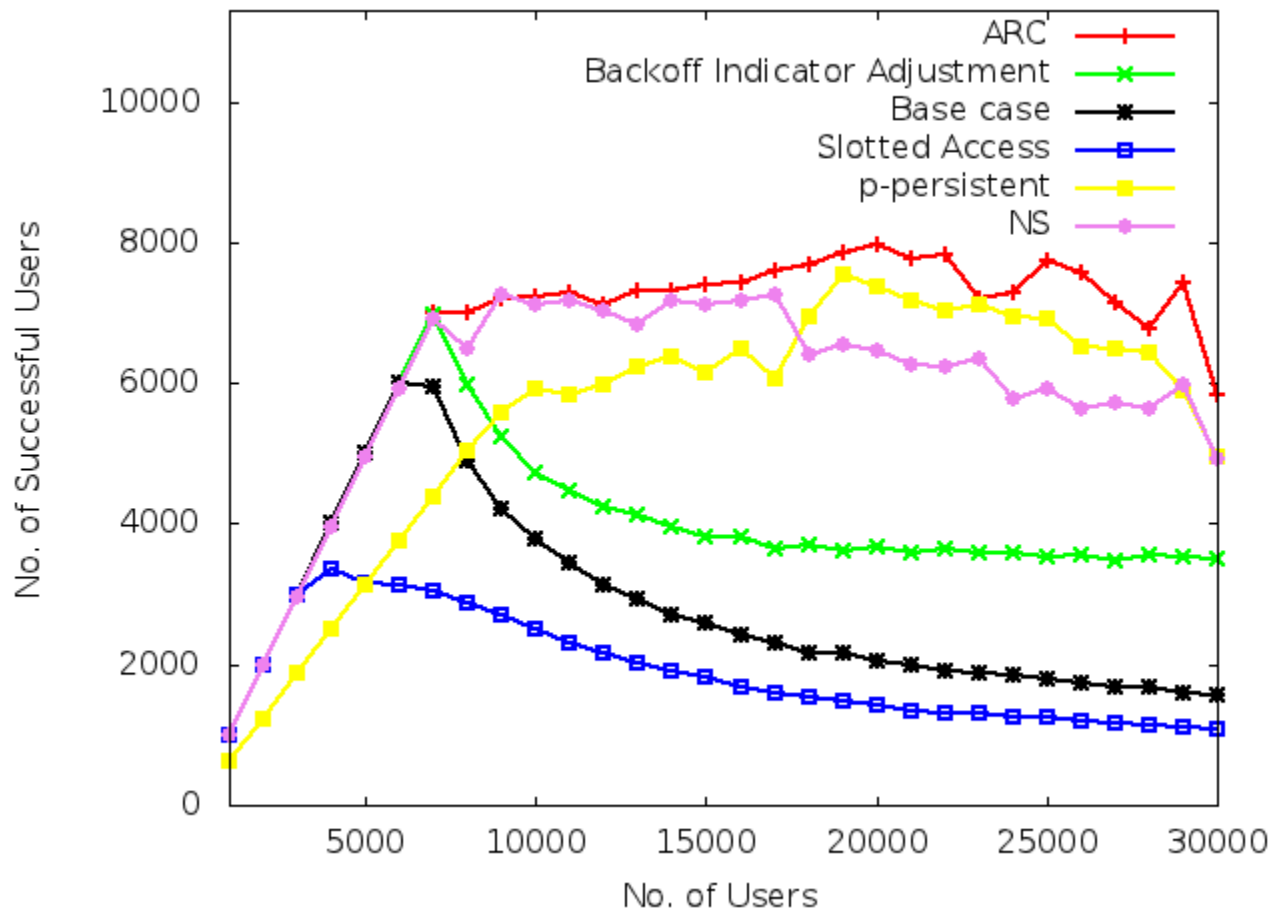


Simulation Setup



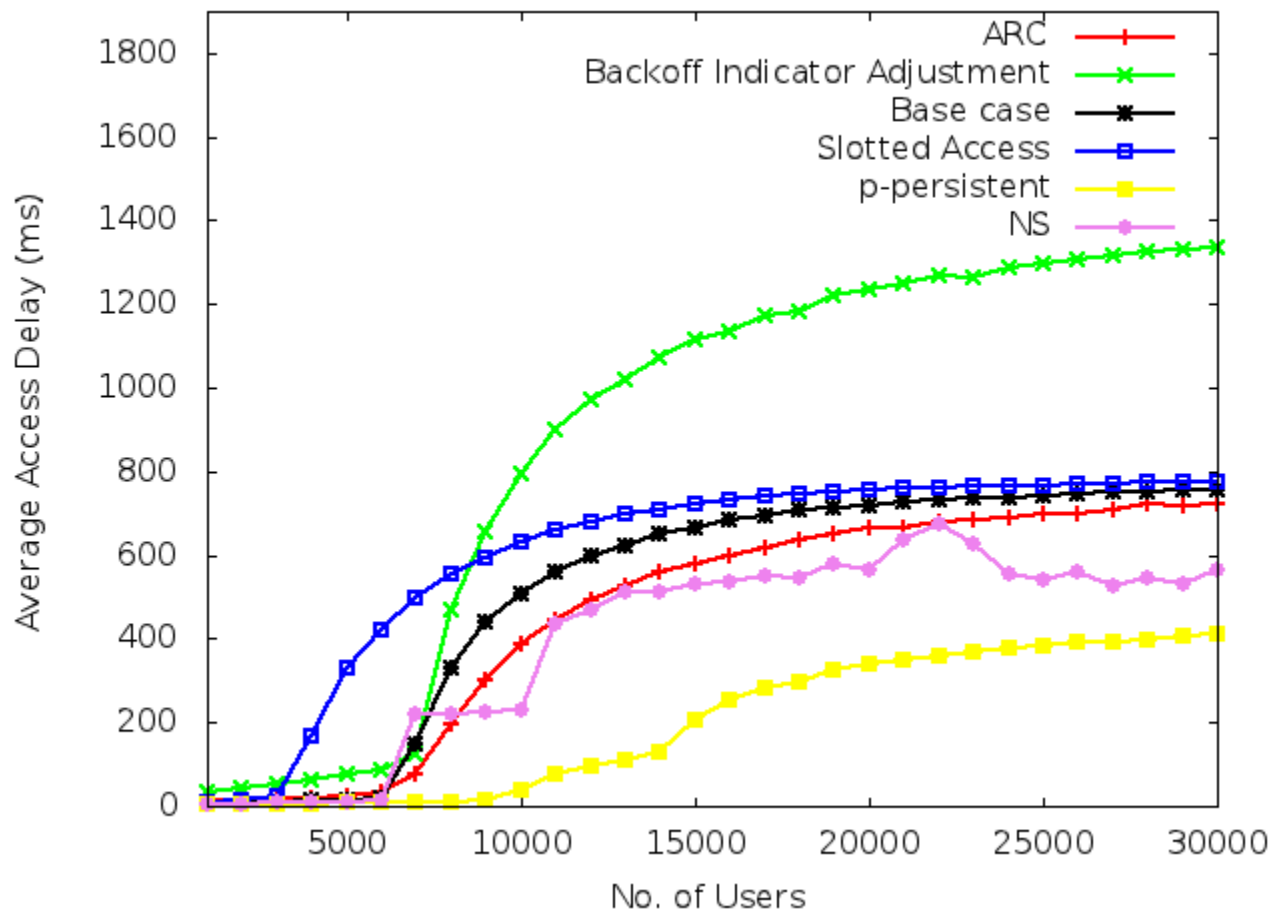
Parameters	Values
Number of Preambles	54
Number of MTC devices	10000 to 30000
Number of preamble retransmissions	15
Preamble detection probability	$1 - 1/e^i$ where i is the i^{th} preamble transmission
No. of RACH opportunities per frame	1
Simulation Time	10s
BackOff Indicator	120ms
Traffic Arrival Distribution	Beta Distribution
λ_1, λ_2	3, 7

Simulation Results: Number of successful devices



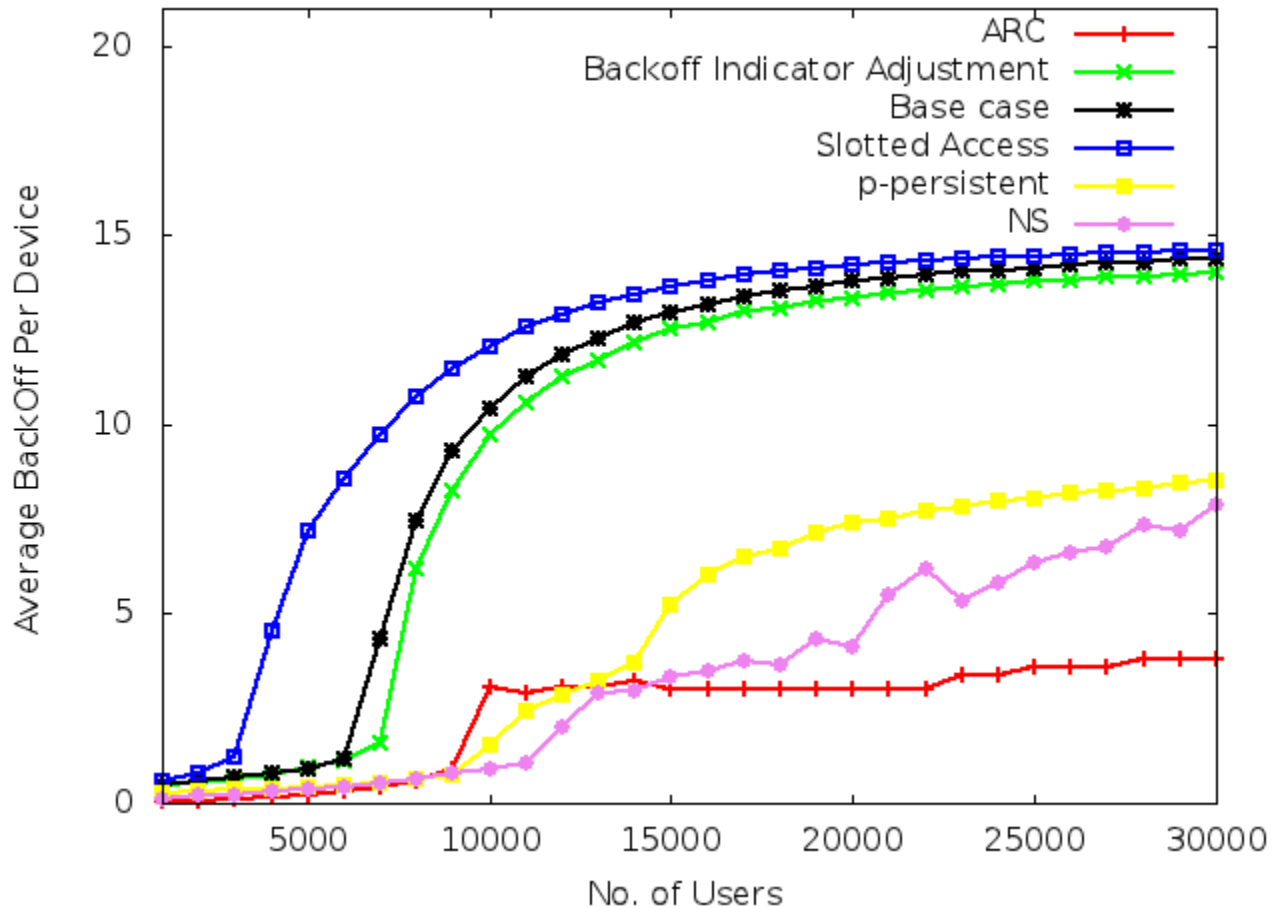
- **4% increase in performance of ARC compare to p -persistent in scenario 2.**

Simulation Results: Average Access Delay



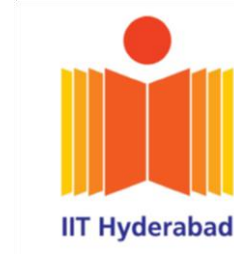
- **ARC performs lower than p-persistent because of frequent occurrence of EAB**

Simulation Results: Average Backoff per device



- **40% increase in performance compare to NS**

Conclusion and Future Work



- For low congestion, NS is the best option.
- ARC performs best in all congestion scenarios.
- In future, we are planning to work on removal of sudden spikes as soon as EAB is removed in case of high congestion.

Acknowledgements



- This work was funded by the Deity, Govt. of India (Grant No. 13(6)/2010CC&BT)
- IIT Hyderabad

Thank
You

- QUESTIONS
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