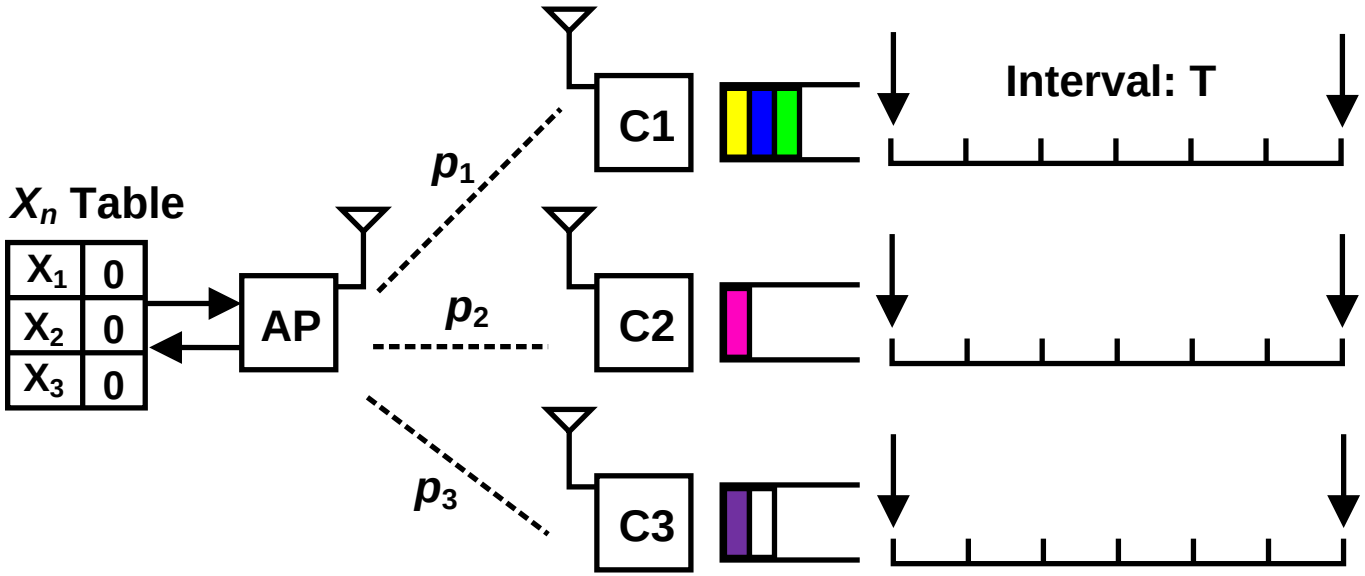
Scheduling for Uplink Transmissions with Point Coordination Function

Dongni Han, Ping-Chun Hsieh, and Tao Zhao

March 31, 2016

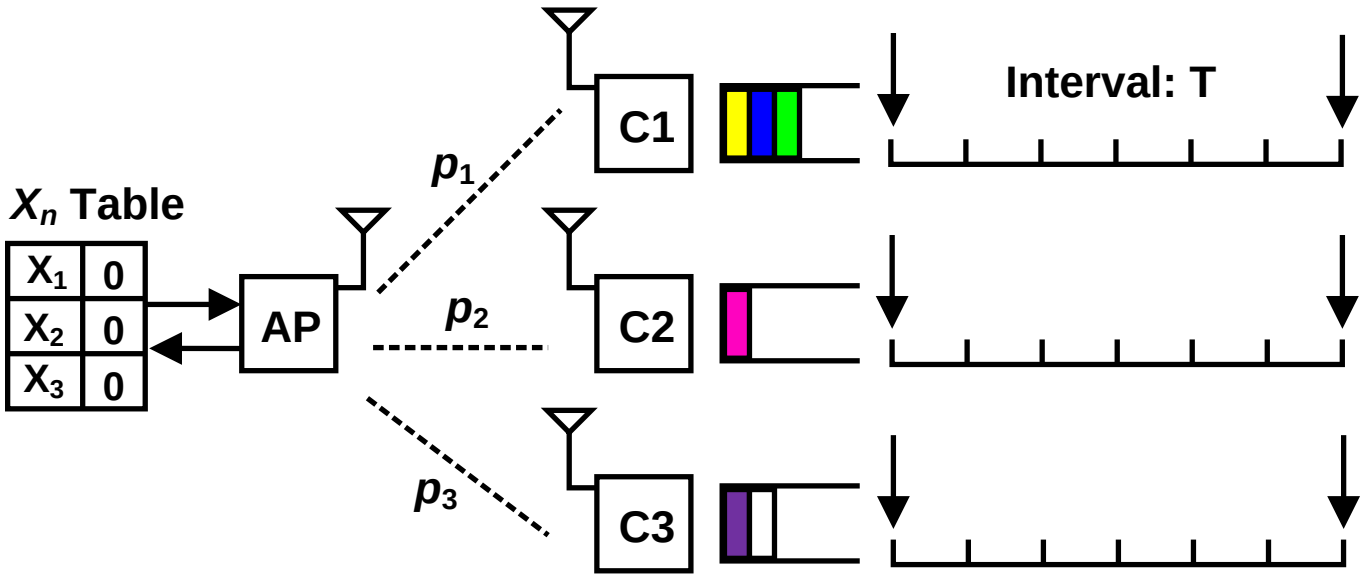
Uplink Transmissions

- One AP and N clients
- 1 slot = 10ms; 1 interval = T slots
- Packets generated in the beginning of each interval
- Number of packets follows Unif$\{N_{\min}, N_{\max}\}$
- Real-time and non-real-time traffic



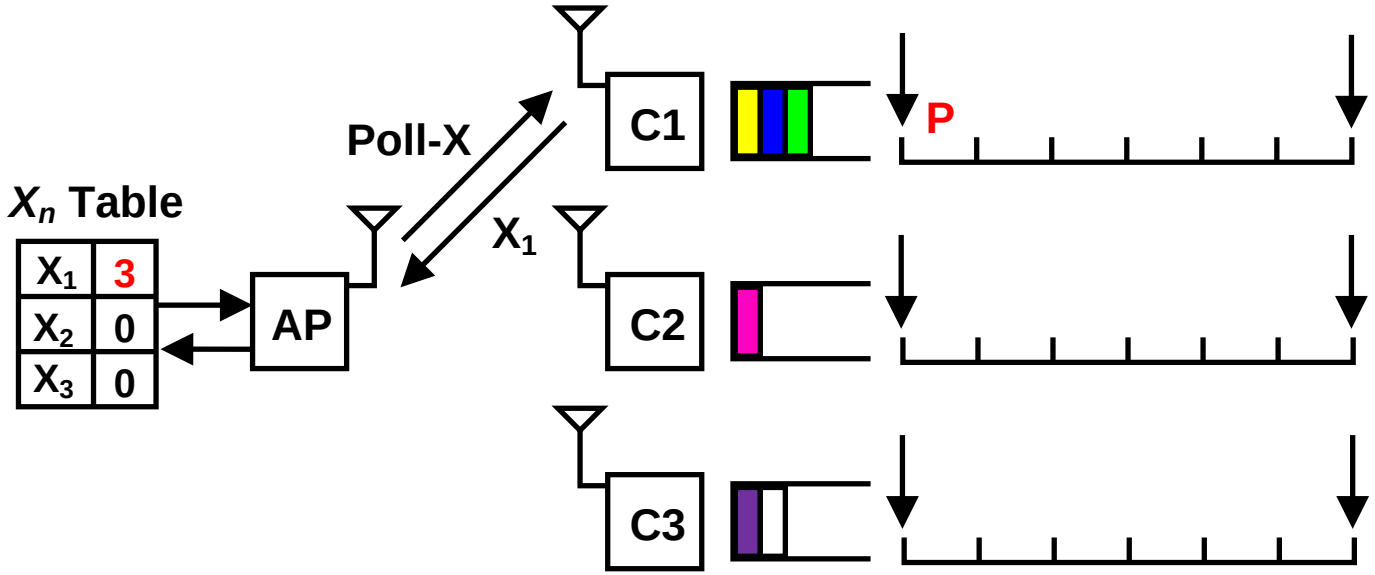
Baseline Policy - A Toy Example

- $N = 3$ and $T = 6$
- $p_1 = p_2 = p_3 = 0.5$
- Real-time traffic
- $X_n(k) =$ queue length at the start of the k-th interval



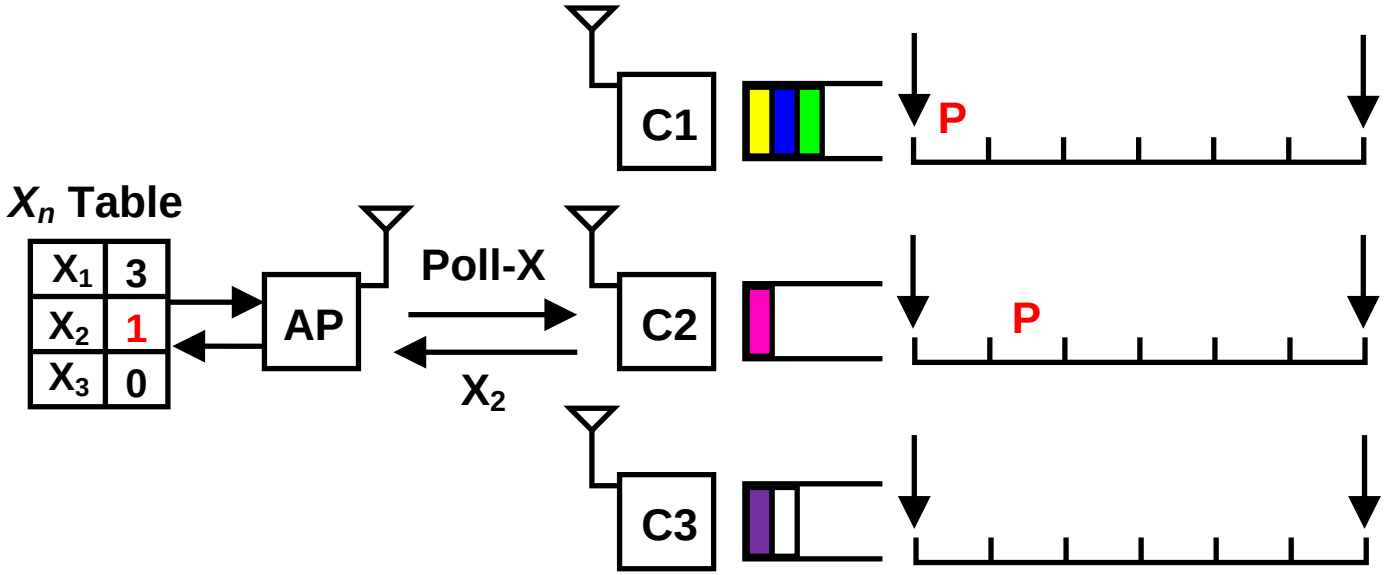
Baseline Policy - A Toy Example

- Phase 1: AP polls X_n in a round-robin manner



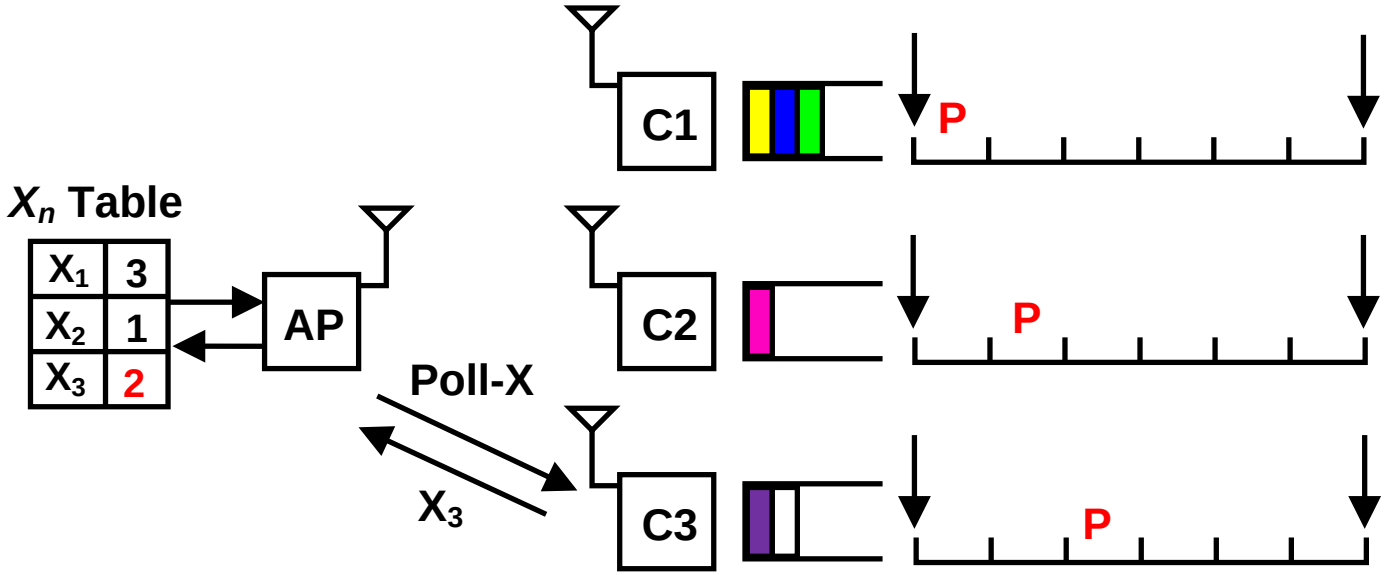
Baseline Policy - A Toy Example

- Phase 1: AP polls X_n in a round-robin manner



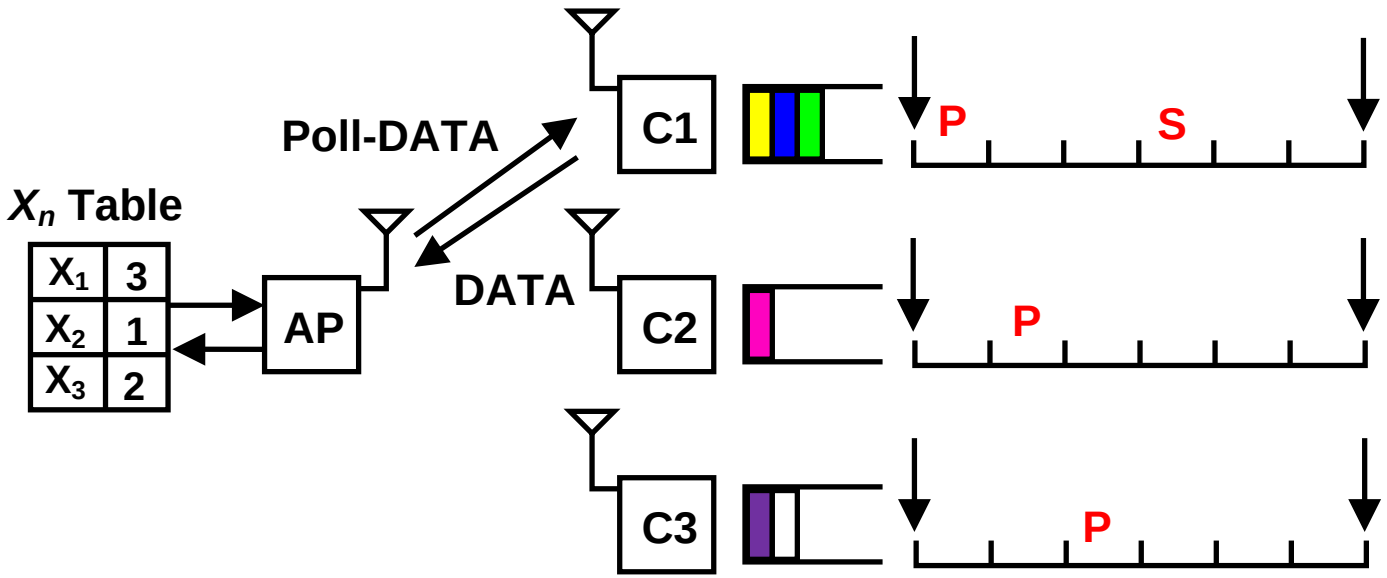
Baseline Policy - A Toy Example

- Phase 1: AP polls X_n in a round-robin manner



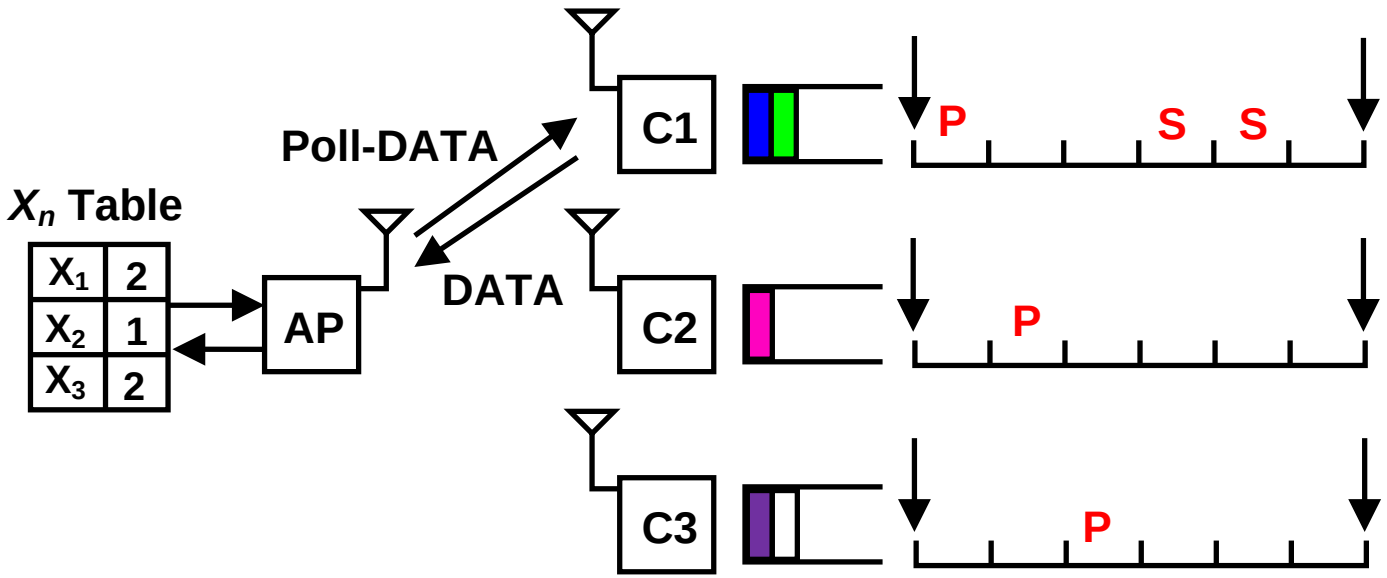
Baseline Policy - A Toy Example

- Phase 2: AP schedules a client based on Max-Weight policy
- Max-Weight: select the client that maximizes $p_n X_n$



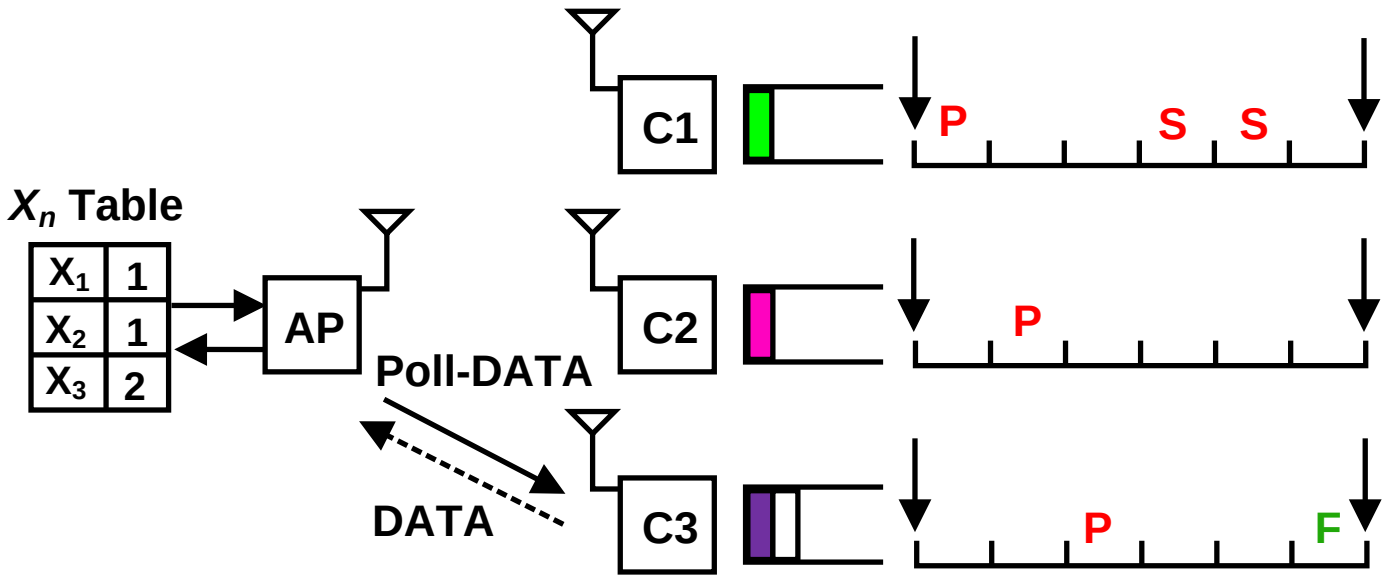
Baseline Policy - A Toy Example

- Phase 2: AP schedules a client based on Max-Weight policy
- Max-Weight: select the client that maximizes $p_n X_n$



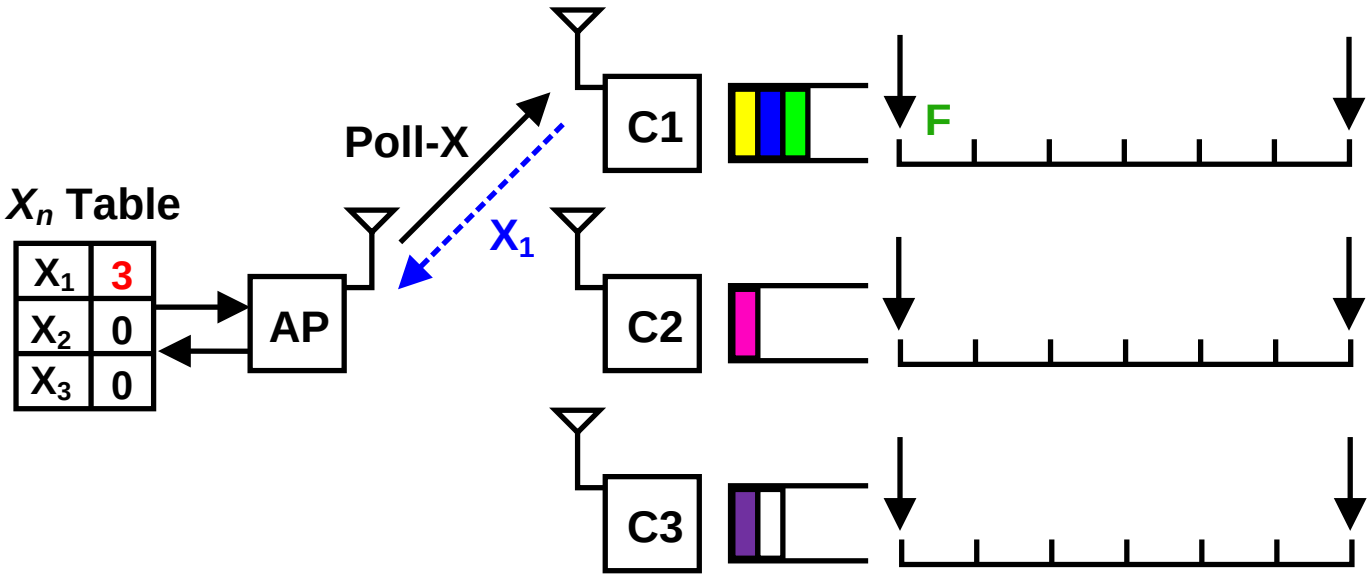
Baseline Policy - A Toy Example

- Phase 2: AP schedules a client based on Max-Weight policy
- Max-Weight: select the client that maximizes $p_n X_n$



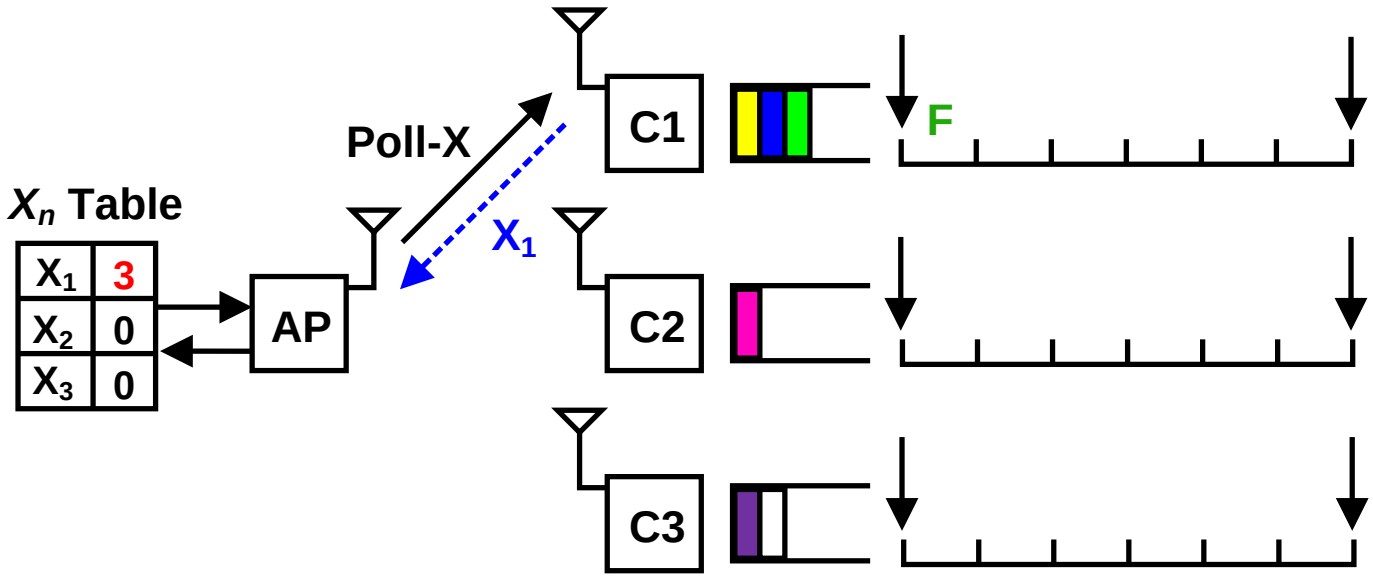
Discussion 1

- What if Poll-X or X_1 is not delivered?



Discussion 1

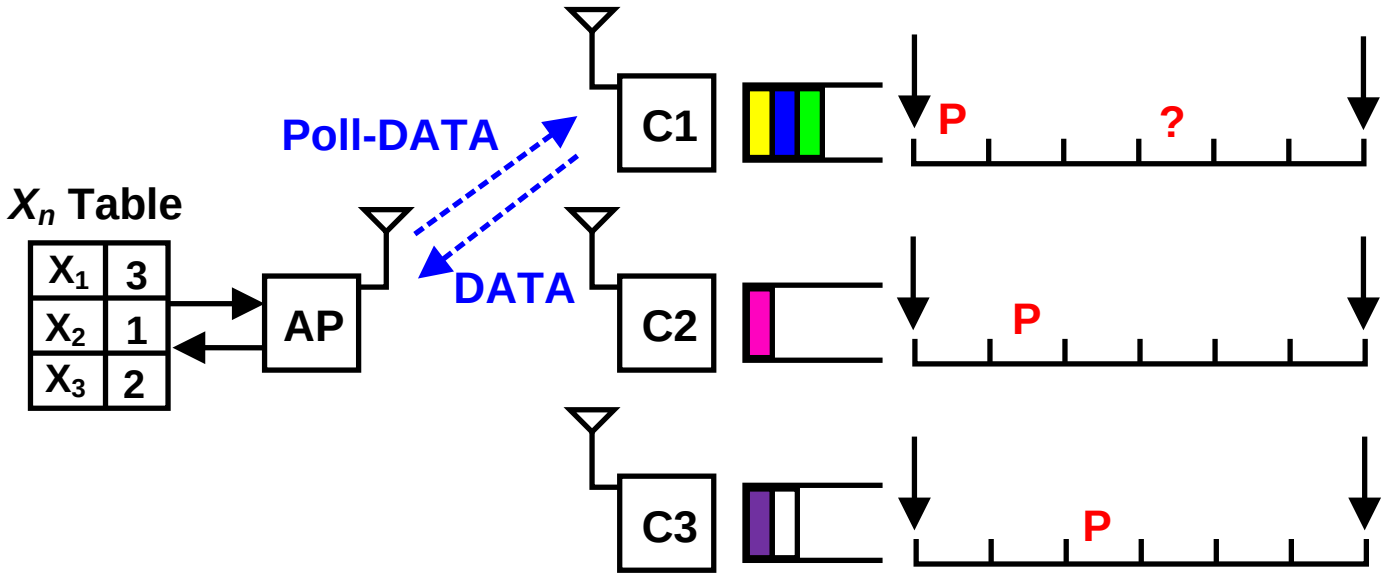
- What if Poll-X or X_1 is not delivered?



- Re-transmit Poll-X until the AP receives X_n
- Option: just set $X_n = 0$

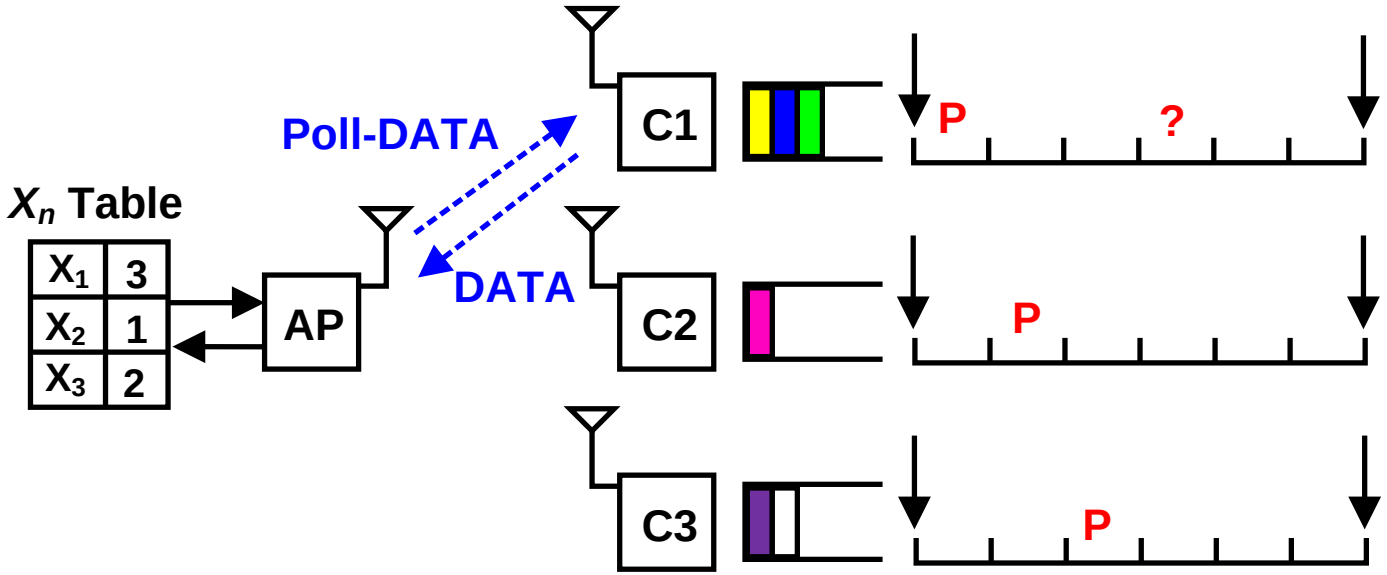
Discussion 2

- How does a client know the DATA packet is delivered?
- Do we need an application-layer ”ACK” for AP?



Discussion 2

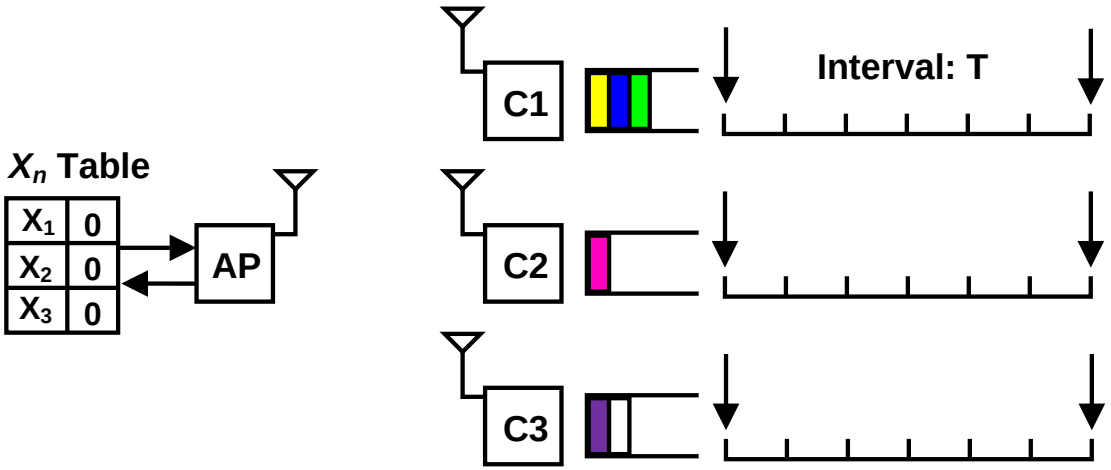
- How does a client know the DATA packet is delivered?
- Do we need an application-layer ”ACK” for AP?



- Put ”expected packet ID” in Poll-DATA packets

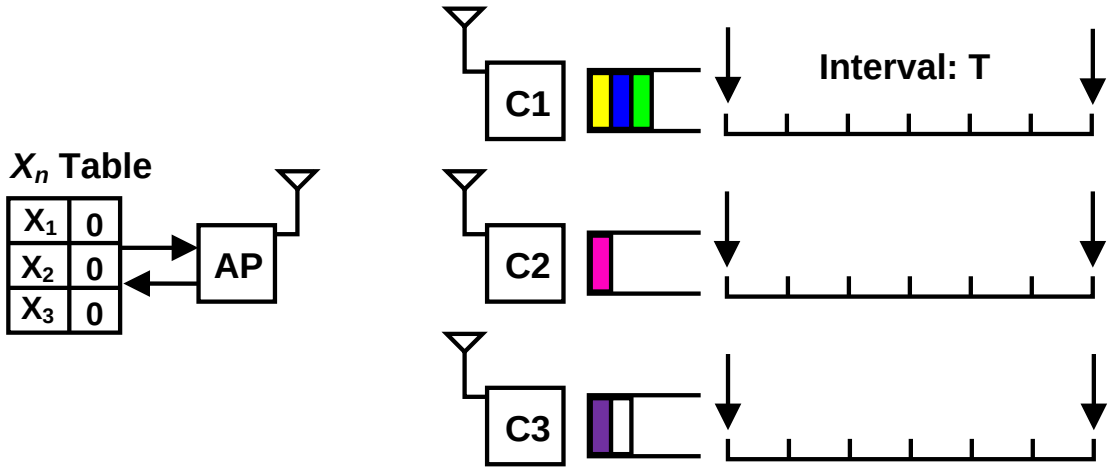
Discussion 3

- For non-real-time traffic, what does "X_n" mean?
- There is no application-layer ACK from AP



Discussion 3

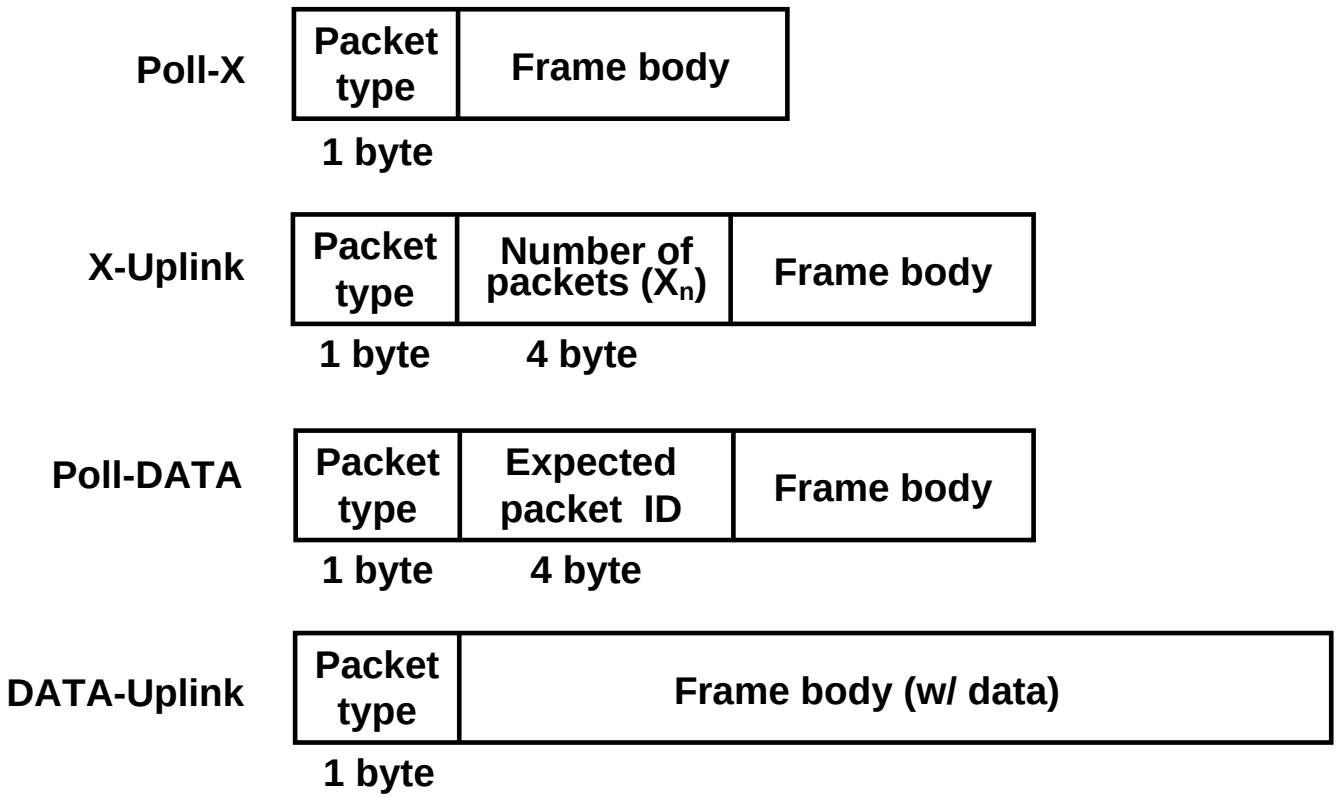
- For non-real-time traffic, what does "X_n" mean?
- There is no application-layer ACK from AP



- $X_n :=$ total number of packets generated by client n
- $Y_n :=$ total delivery of data packets from client n (maintained by AP)
- Max-Weight: choose n that maximizes $p_n(X_n - Y_n)$

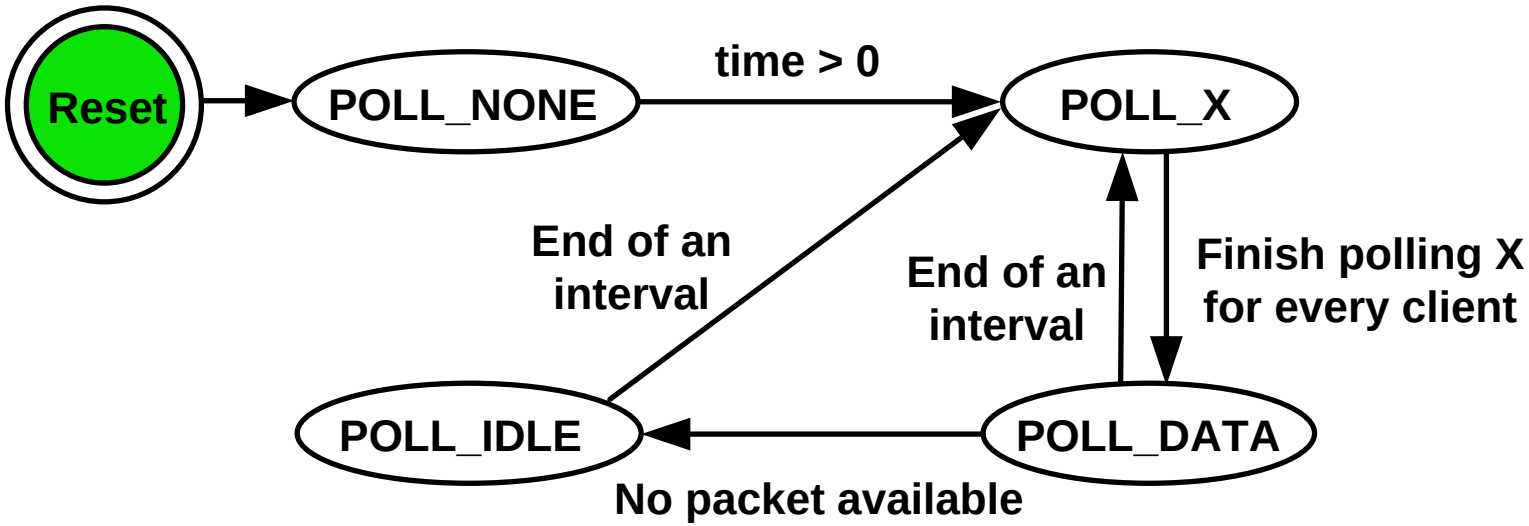
NS-2 Implementation: Packet Types

- AP: Poll-X and Poll-DATA
- Client: X-Uplink and DATA-Uplink



NS-2 Implementation: State Machine

- AP is controlled by the state machine as follows.



Pros and Cons

Pros:

- Simple polling scheme
- AP is work-conserving in phase 2

Cons:

- Overhead due to polling
- Channel utilization for data packets is low
- Not practical when N is large

Simulation Results: Network Capacity

- $N = 2$ and $T = 10$
- Reliable channel: $p_1 = p_2 = 1$ (symmetric)
- $N_{\max}$ ranges from 1 to 12
- Non-real-time traffic

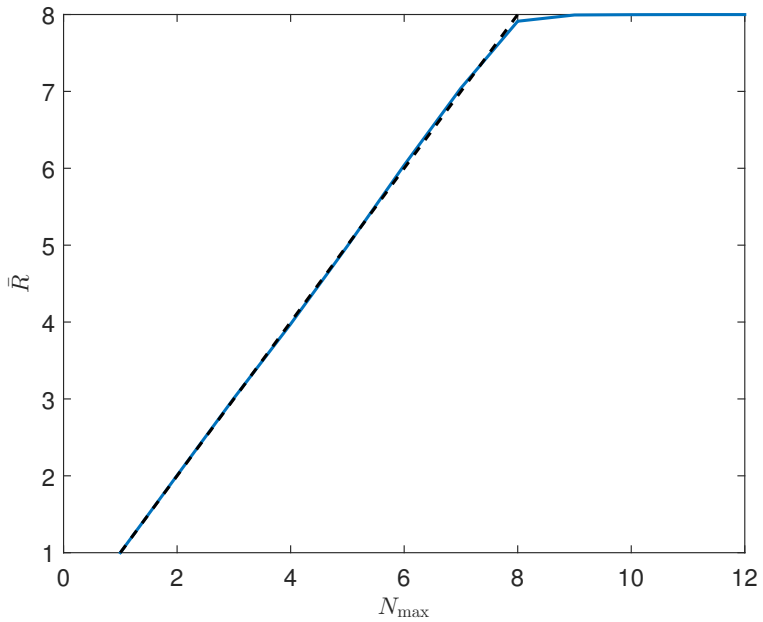


Figure: Phase 1 polling reduces the capacity.

Simulation Results: Network Capacity

- $N = 2$ and $T = 10$
- Reliable channel: $p_1 = p_2 = 1$ (symmetric)
- $N_{\max}$ ranges from 1 to 20
- Real-time traffic

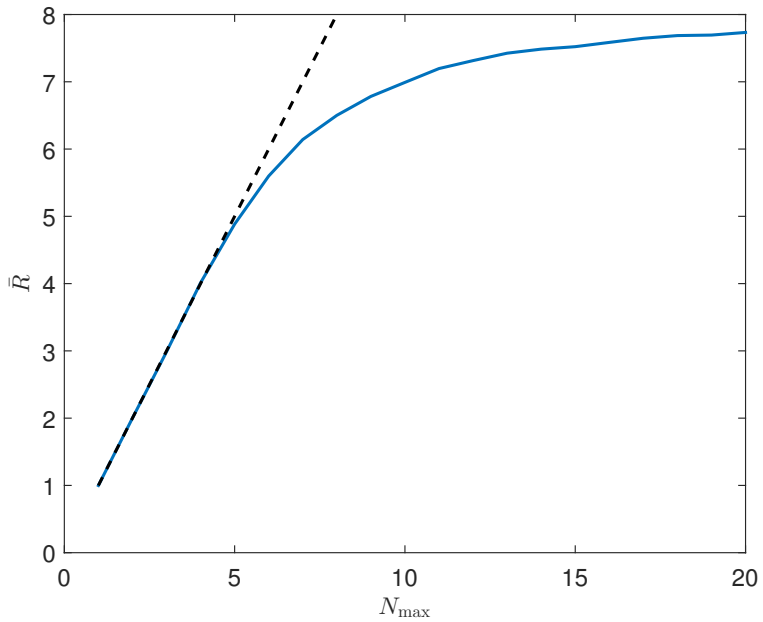


Figure: Packet deadline reduces the capacity further.

Simulation Results: Interval Length

- $N = 2$
- Unreliable channel: $p_1 = p_2 \approx 0.57$ (distance 1000 m)
- T ranges from 4 to 16
- Non-real-time traffic

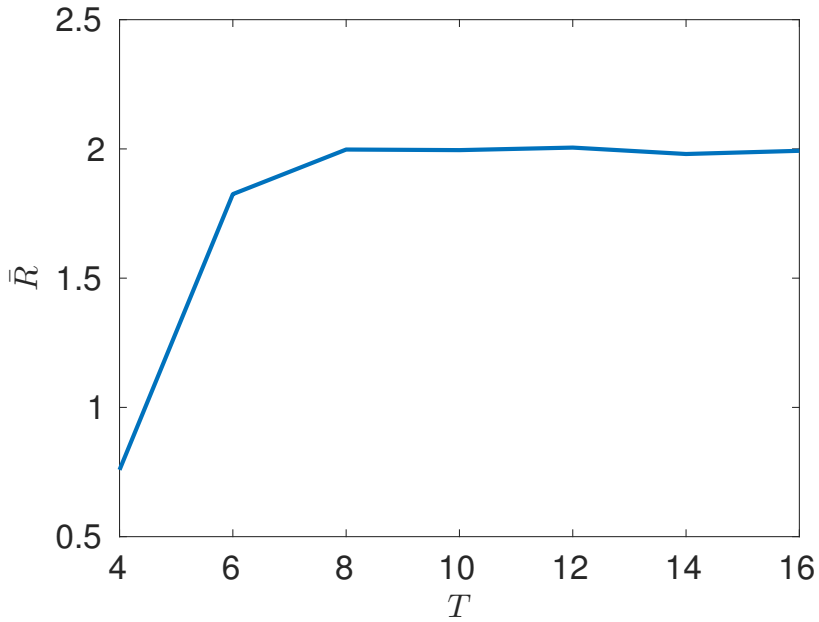


Figure: Interval should be long enough to guarantee deliveries.

Simulation Results: Interval Length

- $N = 2$
- Unreliable channel: $p_1 = p_2 \approx 0.57$ (distance 1000 m)
- T ranges from 4 to 16
- Real-time traffic

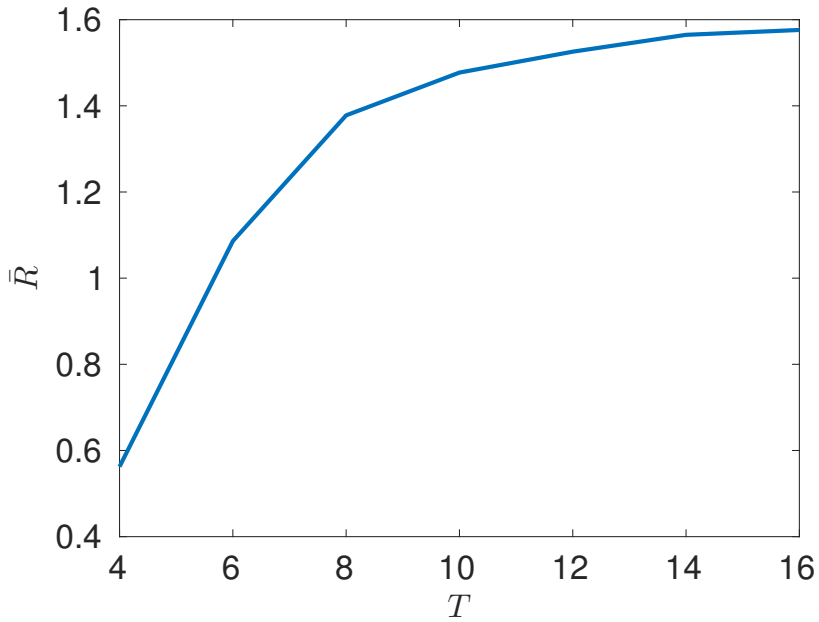


Figure: Interval should be longer when packet can expire.

Simulation Results

- Fix $T = 10$
- Unreliable channel: $p_1 = p_2 \approx 0.57$ (distance 1000 m)
- N ranges from 1 to 5
- Non-real-time traffic

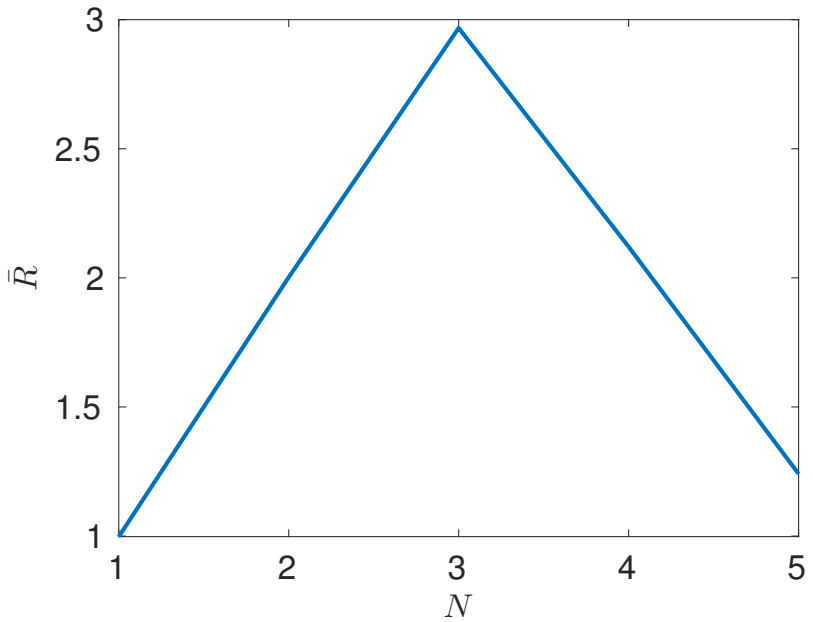


Figure: Performance degrades severely with more clients.

Simulation Results

- Fix $T = 10$
- Unreliable channel: $p_1 = p_2 \approx 0.57$ (distance 1000 m)
- N ranges from 1 to 5
- Real-time traffic

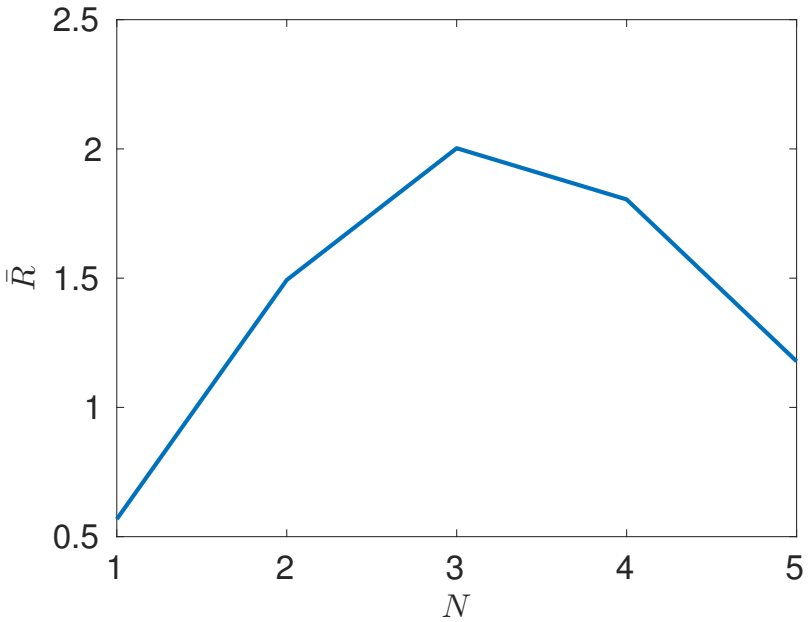


Figure: Performance is worse and also degrades with more clients.

Conclusion

- The baseline policy incurs huge overhead especially with large N and small T
- We need a smarter policy!