A Dynamic Hybrid MAC Protocol of TMDA and CSMA/CA

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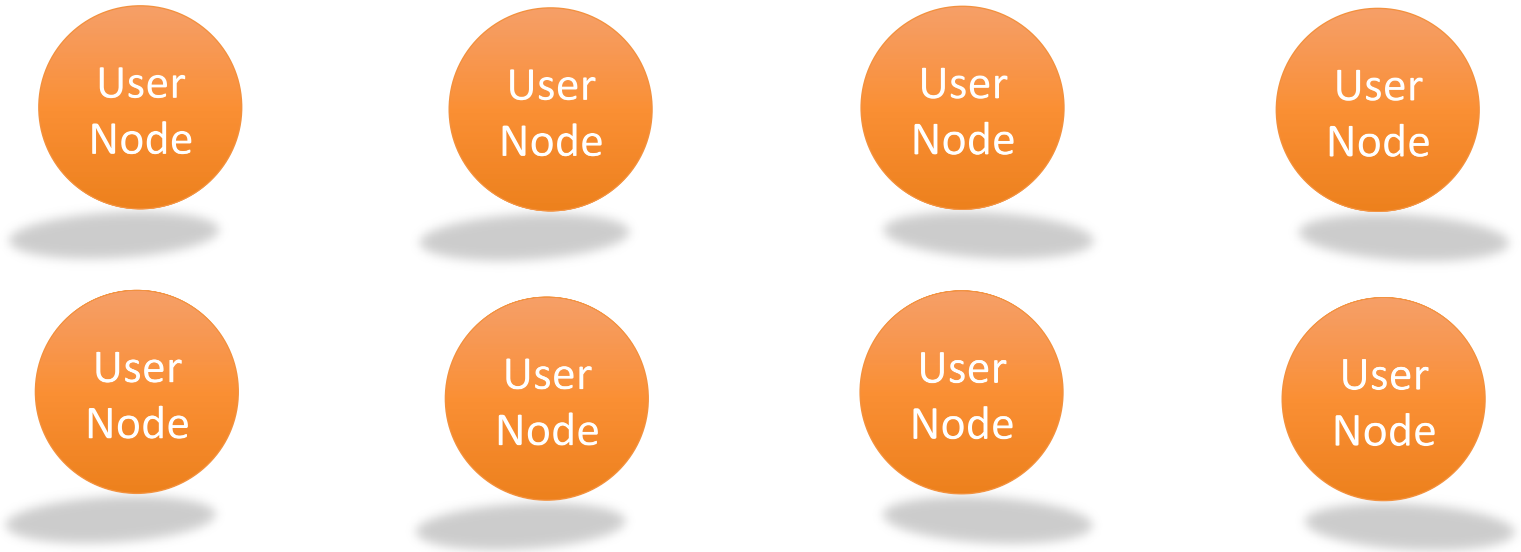
- ✓ Introduction.
- System Model.
- Mathematic Analysis.
- Simulation.
- Conclusion & Future Work.

Introduction.

- **Background of MAC.**
- MAC (Medium Access Control).
- What does MAC layer do? **Scheduling.**



Introduction.

- **Motivation.**
- CSMA/CA model: the fewer nodes → the higher channel utilization.
- TDMA model： the more nodes → the higher channel utilization.
- **SO!!!**
- **Why not a hybrid model?**
- **Relatively high channel utilization ALWAYS.**
- **Not relative with node number.**

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System Model.

- **Step 1. Information Collection.**
- Step 1(a). Center Node: **broadcast** the signal to all nodes.
- Step 1(b). Nodes: if new ones transmit, send a **RTS**.
- Step 1(c). Center Node: when RTS received, it send back an **ACK**.

System Model.

- **Step 2. Scheduling.**
- Scheduling consists of two parts of decisions ---- Order and Period.
- Step 2(a). Transmission Order.
- In the Center Node, there is a **Transmission Queue**, which contains the information of transmitting user nodes.

11	72	3	24	91	54

CurNodeNum = 6

11	3	24	91	54	29	76	18

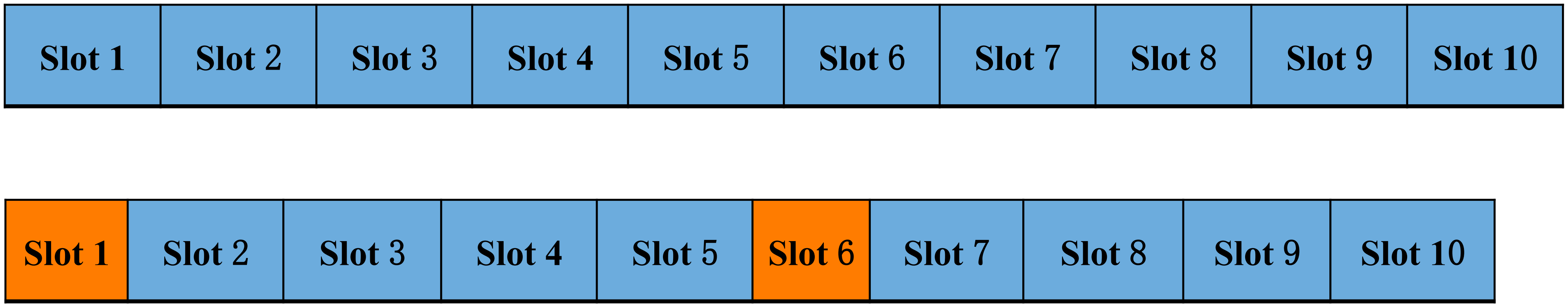
CurNodeNum = 8

System Model.

- **Step 2. Scheduling.**
- Scheduling consists of two parts of decisions ---- Order and Period.
- Step 2(b). Changes of Transmission Period.
- The length of transmission period ↔ The current number of nodes.
- The algorithm is shown as following:
  - While(CurNodeNum>time_period/N_1) time_period*=2;
  - While(CurNodeNum<time_period/N_2) time_period/=2;
- time_period/N_1 → lower bound of CurNodeNum.
- time_period/N_2 → upper bound of CurNodeNum.

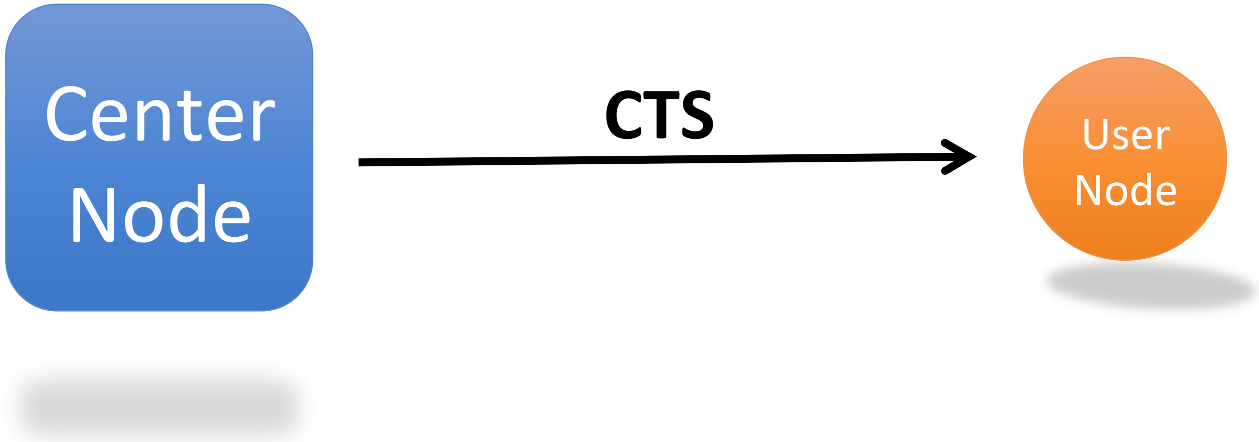
System Model.

- **Step 3. Transmission.**
- Step 3(a). Divide the transmission period into N parts. (N:NodeNum)
  - Set slot_max = M/N. (M: length of transmission period)



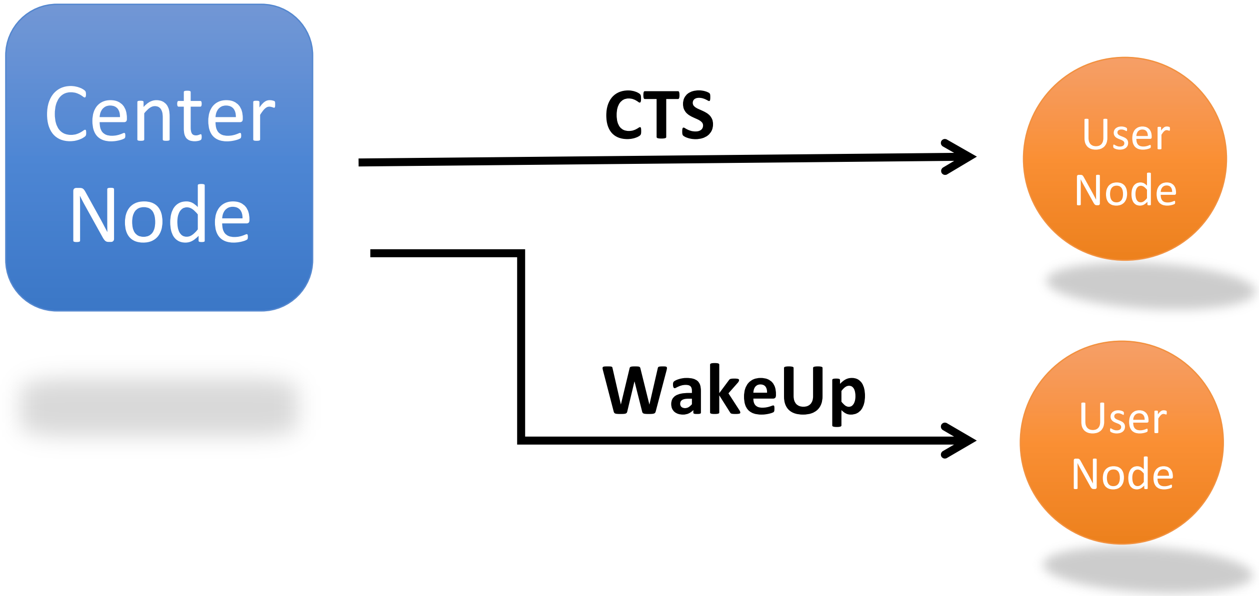
System Model.

- **Step 3. Transmission.**
- Step 3(b). The i^{th} node starts to transmit with a CTS signal.



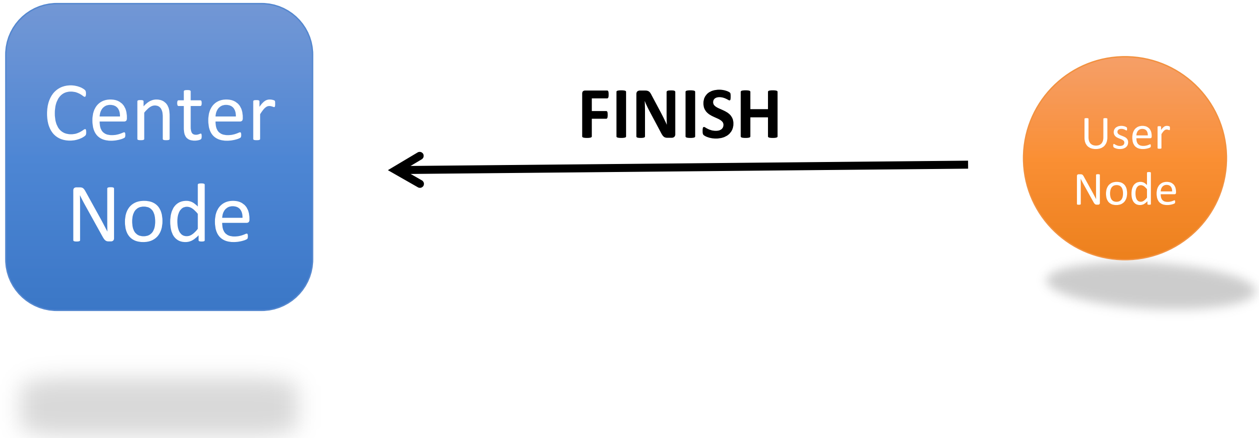
System Model.

- **Step 3. Transmission.**
  - Step 3(c). Wake up the i+1th node just before the ith node transmits.



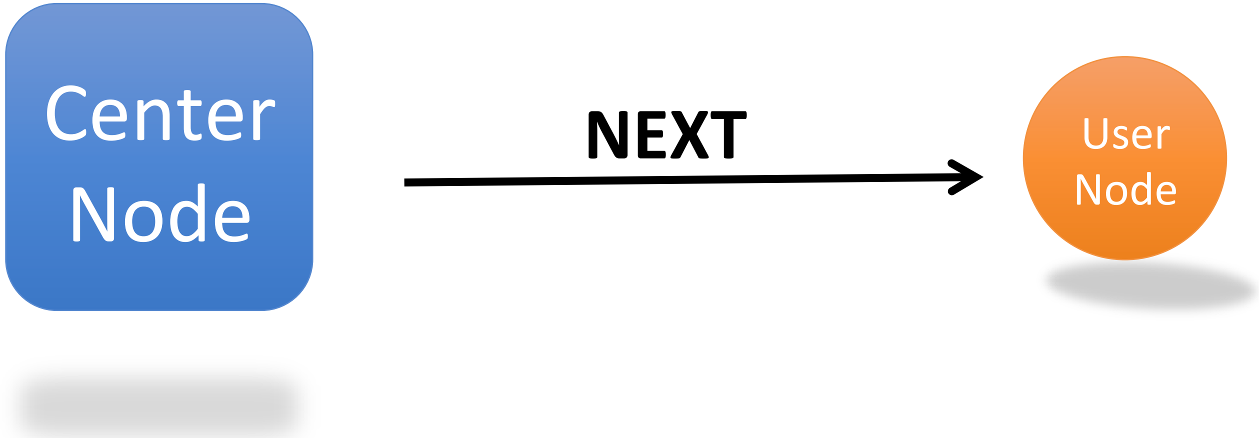
System Model.

- **Step 3. Transmission.**
- Step 3(d). Handle those nodes who finish transmitting ahead.
  - When a node finishes transmitting ahead, it will send back a FINISH signal back to center node in order to let next node to transmit immediately.



System Model.

- **Step 3. Transmission.**
- Step 3(d). Handle those nodes who finish transmitting ahead.
  - After Center Node knows this User Node has finished the transmission, it will send a NEXT signal to this User Node to put it in the sleep mode.



System Model.

- **Step 3. Transmission.**
- Then we can get two different cases:
- Case a: A transmitting node doesn't finish transmission in a time slot.

- Case b: A transmitting node finishes transmission in a time slot.

System Model.

- **Step 3. Transmission.**
- Then we can get two different cases:
- Case a: A transmitting node doesn’t finish transmission in a time slot.

$$Efficiency_1 = \frac{T_{DATA}}{T_{CTS} + T_{WakeUp} + T_{DATA}}$$

System Model.

- **Step 3. Transmission.**
- Then we can get two different cases:
- Case b: A transmitting node finishes TR in a time slot.

$$Efficiency_2 = \frac{T_{DATA}}{T_{CTS} + T_{WakeUp} + T_{DATA} + T_{FINISH} + T_{NEXT}}$$

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Mathematic Analysis.

- **Part A. Efficiency.**
- As mentioned previously:
- (a) When the transmitting node normally stops transmitting, we get the Efficiency_1 (Eff_1) as following:

$$Efficiency_1 = \frac{T_{DATA}}{T_{CTS} + T_{WakeUp} + T_{DATA}}$$

- (a) When the transmitting node finishes transmission ahead of time, we get the Efficiency_2 (Eff_2) as following:

$$Efficiency_2 = \frac{T_{DATA}}{T_{CTS} + T_{WakeUp} + T_{DATA} + T_{FINISH} + T_{NEXT}}$$

Mathematic Analysis.

- **Part A. Efficiency.**
- And then we assume in one time period T_i:
- The number of n_i nodes are transmitting data.
- The possibility $P(n_i) \rightarrow$ nodes normally stopping their transmission.
- The possibility $1\text{-}P(n_i) \rightarrow$ nodes finishing transmission ahead of time.
- Thusly, we can get the total efficiency as following:

$$Efficiency = \frac{\sum_{i=1}^{N} \left[n_i \cdot P(n_i) \cdot Eff_1 + n_i \cdot (1 - P(n_i)) \cdot Eff_2 \right]}{\sum_{i=1}^{N} n_i}$$

Mathematic Analysis.

- **Part A. Efficiency.**

$$Efficiency = \frac{\sum_{i=1}^{N}\left[n_i \cdot P(n_i) \cdot Eff_1 + n_i \cdot (1 - P(n_i)) \cdot Eff_2\right]}{\sum_{i=1}^{N} n_i}$$

- The possibility $P(n_i)$ ↔ The node number n_i.
- n_i↑ then $P(n_i)$↑.
- n_i↓ then $1\text{-}P(n_i)$↑.

Mathematatic Analysis.

- **Part B. Energy Consumption.**
- In the Wireless Sensor Network, energy saving is an important issue.

$E_{Polling}$

$E_{Listening}$

$E_{Transmitting}$

in CSMA/CA: $E_{Back-Off}$

Mathematic Analysis.

- **Part B. Energy Consumption.**
- In my dynamic hybrid model of TDMA and CSMA:

$$\eta_{hybrid} = \frac{E_{Transmitting}}{E_{Polling} + N_{Listening} \cdot E_{Listening} + E_{Transmitting}}$$

- HOWEVER!
- $N_{Listening} = 1$ can make sure the fact as following:
- $N_{Listening} \cdot E_{Listening}$ is quite a small amount of energy.

Mathematic Analysis.

- **Part B. Energy Consumption.**
- Compared with TMDA and CSMA model:
- TMDA model: $\eta_{TDMA} \approx \frac{E_{Transmitting}}{E_{Transmitting}} = 1$
- CSMA model: $\eta_{CSMA} = \frac{E_{Transmitting}}{E_{Polling} + E_{Listening} + E_{Transmitting} + E_{Back-Off}}$
- Therefore: $\eta_{TDMA} > \eta_{hybrid} >> \eta_{CSMA}$

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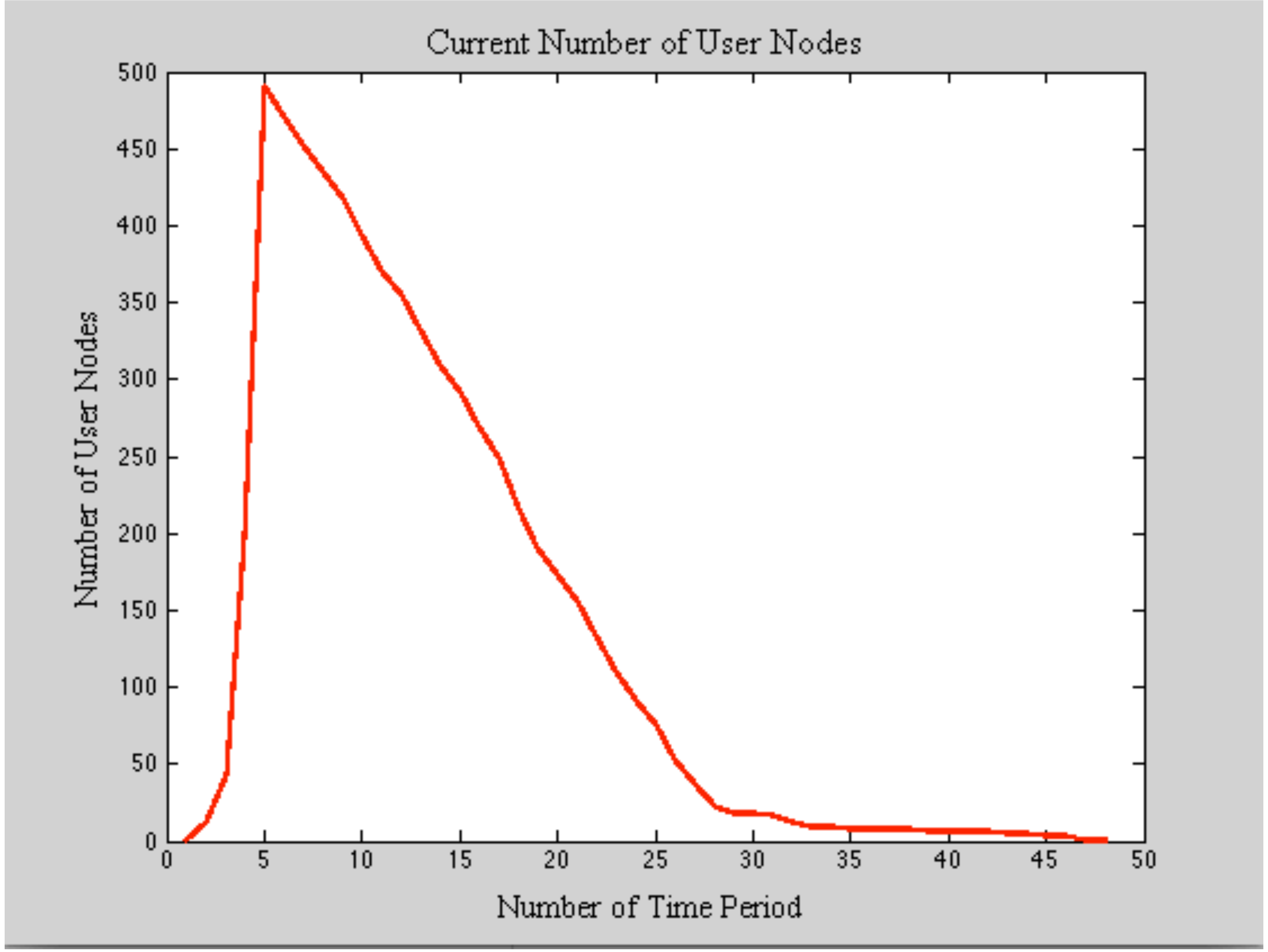
Simulation.

- **A. Process.**
- Arrival Time of Users: node_time = rand[0,MAXtime];
- Data packages of Users: node_package = rand[0,MAXpackage];
- Number of Users: node_number = constant.

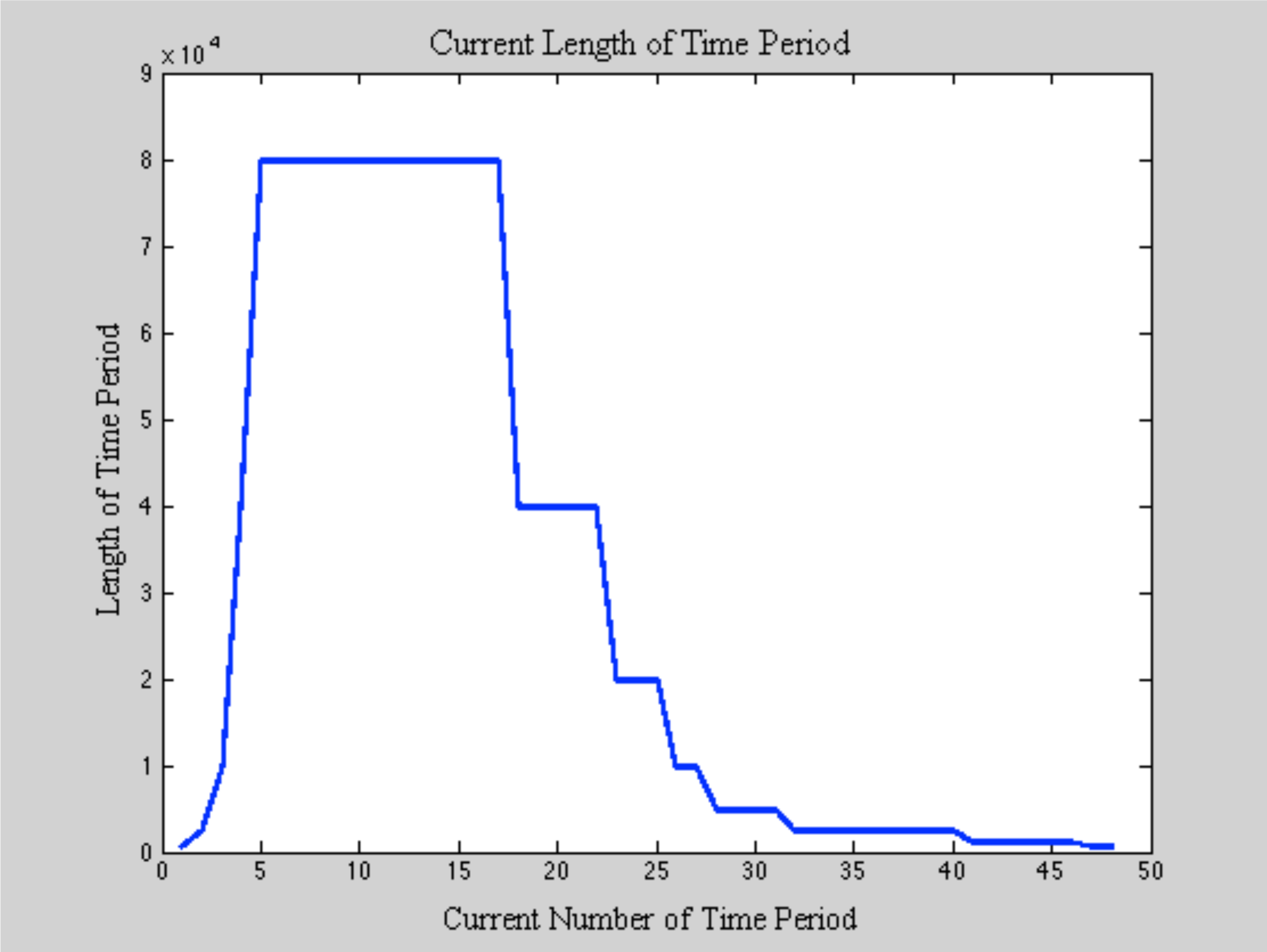
Simulation.

- **A. Process.**
- X: Time Period.
- Y: Current Node Number.
- Node = 500.



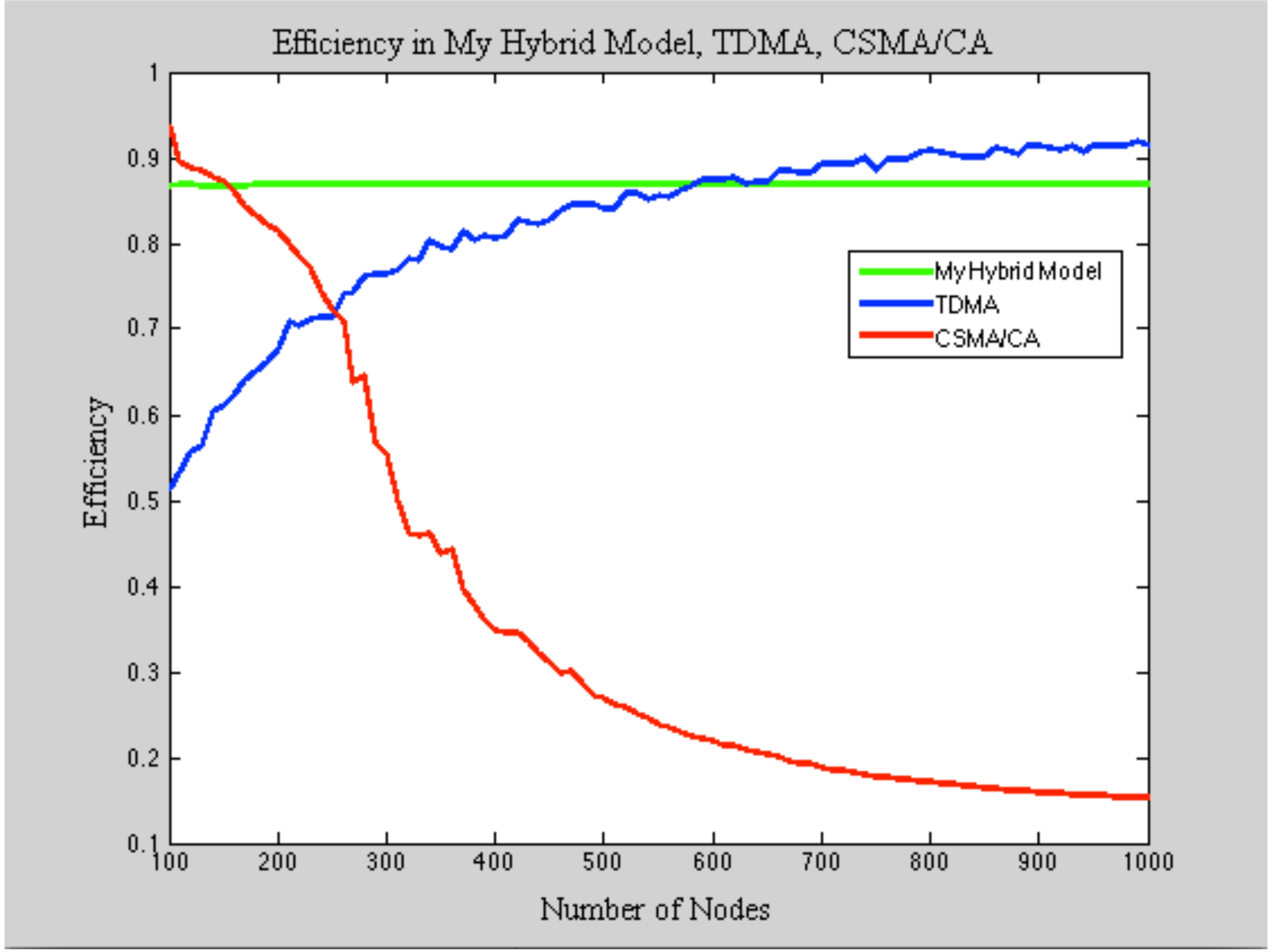
Simulation.

- **A. Process.**
- X: Time Period.
- Y: Time Period Length.
- Node = 500.



Simulation.

- **B. Efficiency.**
- X: Number of Node.
- Y: Efficiency.
- Node Number:
- 100:10:1000.



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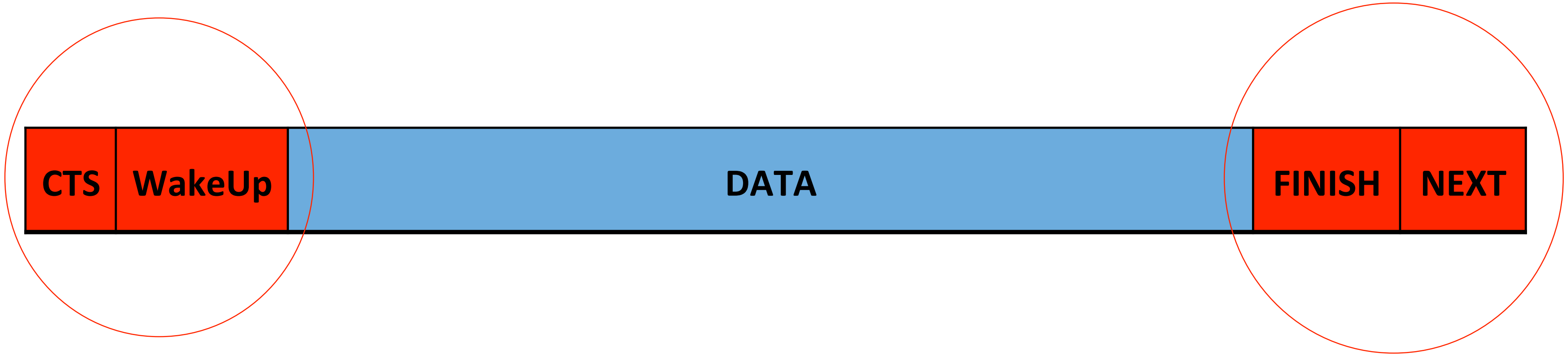
Conclusion & Future Work.

- **Conclusion.**
- The dynamic hybrid model of TDMA and CSMA/CA adds the algorithms of CSMA/CA to the TDMA model.



- Also the length of every time period is up to the current number of transmitting nodes.

Conclusion & Future Work.

- **Conclusion.**
- The simulation results show that:
- (1) There is a close relevance between the number of transmitting nodes and the length of every time period.
- (2) The performance of this dynamic hybrid model is not changing greatly with the number of nodes. This model has the best performance on average.

Conclusion & Future Work.

- **Future Work.**
- (1) Simulation with better tools like NS3.
- (2) Even implementation in the real-time systems.
- (3) Improve this hybrid model in the further step.

THANK YOU FOR LISTENING

Q & A