

Scheduled Access with Fixed-Duration Cycles for Enhanced PLCA

IEEE 802.3 PLCA Enhancements Study Group
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Background: PLCA Operation & Timing Requirements

PLCA operation

- Stations receive exclusive transmit opportunities (TOs) sequentially
- PLCA provides fair access, with a common worst-case latency bound for all stations*

Timing characteristics

- Latency bounds depend on station count and maximum frame sizes*
- Cycle duration depends on instantaneous station activity
- TO start times, within a cycle, depend on preceding transmissions and TO yielding

Application requirements

- Timing requirements differ between stations and between traffic classes within a station
- Existing latency and latency-variation bounds may not satisfy demanding control-loop requirements

Enhancement direction

- Improve access latency and latency variation per node and per class of service within a node

*Assumption: Each station may transmit at most one frame per TO

Differentiated Access: Timing and Latency Considerations

Differentiated access

- Existing contributions enable differentiated access by adjusting station participation frequency
- These mechanisms can reduce access latency and latency variation

Remaining timing considerations

- **Activity-dependent timing:** In approaches retaining activity-based TO progression, cycle duration and access timing remain dependent on the activity and transmission durations of eligible stations
- **Latency variation limitation:** Consequently, a station can experience different access latencies as other stations' activity changes
- **Latency bound limitation:** Even infrequent best-effort transmissions must be accounted for. Without deterministic access timing or preemption, the worst-case access latency bound must account for the transmission duration of a maximum-size best-effort frame

Proposed Enhancement: Fixed-Duration Cycles with Scheduled Access

❑ Fixed-duration access cycles

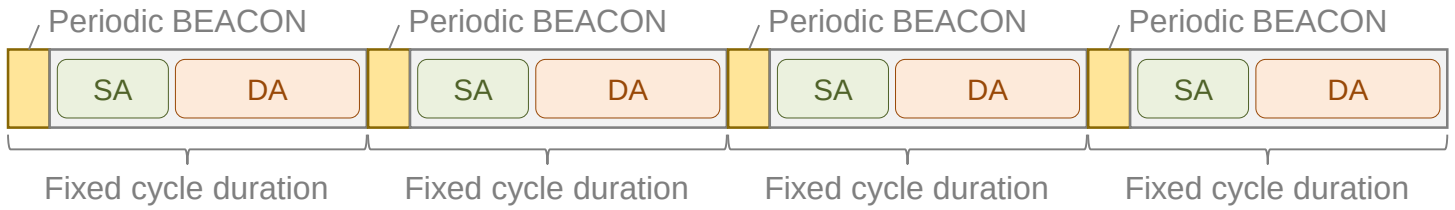
- Time-based BEACON transmissions establish fixed-duration access cycles
- Each access cycle comprises a **scheduled access phase** followed by a **dynamic access phase**

1) Scheduled Access (SA) Phase

- The scheduled access phase occurs at the beginning of each access cycle and has a predetermined duration, which may differ between access cycles
- Scheduled TOs have predetermined start times and durations within this phase

2) Dynamic Access (DA) Phase

- The dynamic access phase occupies the remaining duration of each access cycle
- Dynamic TOs progress sequentially based on station activity, following the PLCA access procedure
  - A transmission may start only if it can complete within the remaining cycle time
  - One round of dynamic TOs may span multiple access cycles

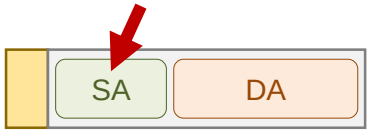


Terminology: Access Participants

These terms are introduced to facilitate the description of this proposal

- **Participant:** A logical unit to which TOs are allocated. It may represent all traffic of a station, a traffic class within a station, or an individual flow
- **Scheduled participant:** A participant allocated scheduled TOs during the scheduled access phase
- **Dynamic participant:** A participant allocated (dynamic) TOs during the dynamic access phase
- A station may host one or more participants, including both scheduled and dynamic participants

Scheduled Access Phase

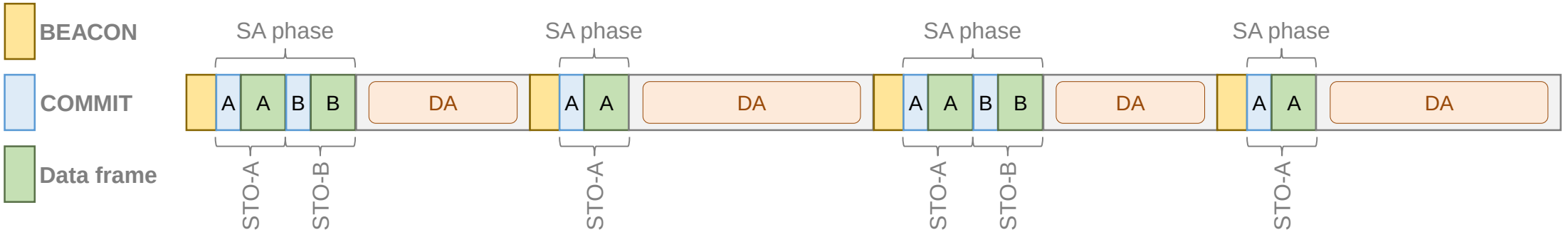


Scheduled TO (STO) allocation

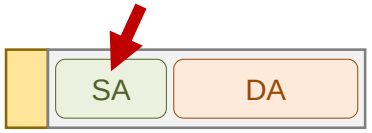
- Each scheduled participant receives an STO every K access cycles, according to its cycle time (configured service period)
- Each STO starts at a predetermined offset within the access cycle

Transmission procedure

- During its STO, a participant with a pending frame may transmit COMMIT to reserve the medium, followed by the data frame
- Subsequent STOs start at their configured times, regardless of whether preceding STOs were used



Scheduled Access Phase



Scheduled capacity reuse

- An unused **final** STO may be yielded, allowing the dynamic access phase to begin earlier
- Unused capacity in a **non-final** STO may be used by a dynamic participant, provided its complete transmission finishes before the next STO begins

The mechanism for enabling such reuse within a non-final STO is not detailed in this presentation

Scheduled Access Phase



Timers and counters

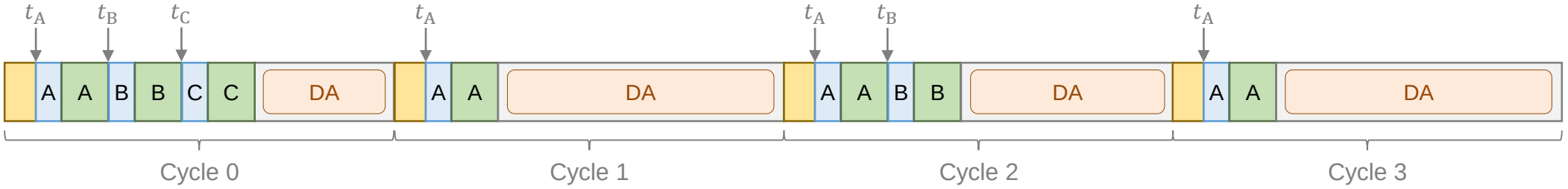
- **BEACON timer:** Triggers BEACON transmissions at fixed intervals
- **Cycle counter:** Identifies the current access cycle within the repeating schedule (hypercycle). Advances at each BEACON and wraps after the final cycle.
- **STO timer:** Triggers the assigned STO at the start offset specified by the current schedule entry

Example

- Cycle times: A: $1\ \mathrm{ms}$; B: $2\ \mathrm{ms}$; C: $4\ \mathrm{ms}$
- Access-cycle duration: $1\ \mathrm{ms}$
- Hypercycle duration: $4\ \mathrm{ms}$, comprising four access cycles

Cycle index	Scheduled Participants	STO offset
0	A, B, C	$t_\mathrm{A}, t_\mathrm{B}, t_\mathrm{C}$
1	A	t_A
2	A, B	$t_\mathrm{A}, t_\mathrm{B}$
3	A	t_A

STO offsets are measured relative to the BEACON



Dynamic Access Phase

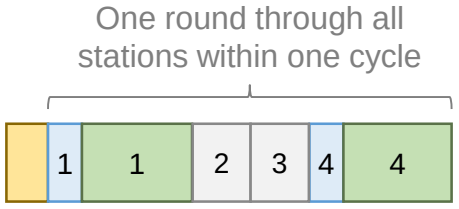


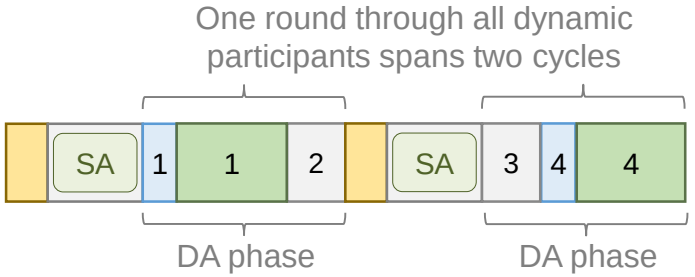


PLCA within fixed-duration access cycles

- After scheduled access completes, dynamic participants receive TOs sequentially within the remaining access cycle time

Standard PLCA	Basic Dynamic Access
Stations receive TOs sequentially	Dynamic participants receive TOs sequentially
During its TO, a station transmits if a frame is pending	During its TO, a participant transmits if a frame is pending **and the complete transmission fits within the remaining access cycle time**
A PLCA cycle comprises one round through all stations	**A round through the dynamic participants may span multiple access cycles**; **progression resumes where it stopped**





Dynamic Access Phase



Dynamic Access Enhancement

Supports differentiated access among dynamic participants and can improve access-latency bounds for those with latency requirements

- Each such participant is assigned a transmission budget, expressed in packets or bits and replenished at the beginning of each of its configured service periods
- Dynamic TO progression restarts from the first participant in each access cycle, with participants ordered according to their latency requirements
- A budget-controlled participant may transmit only if sufficient budget and remaining cycle time are available

Detailed operation may be presented in a future contribution

THANK YOU

