ROLL Working Group
Industrial Deterministic Routing Extension for LLN
draft-wei-roll-scheduling-routing-01

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● The Problem

- RPL is expected to be more suitable for industrial application.

- The requirements from the industrial environment for a routing protocol in Low power and Lossy Networks (LLNs) is analyzed in [RFC5673].

- Determinism is one of the most important requirements in industrial application. In industrial wireless application, cross-layer design needed to be considered to promote the performances of the determinism scheduling, which is not only related to link layer, but also affects the routing.
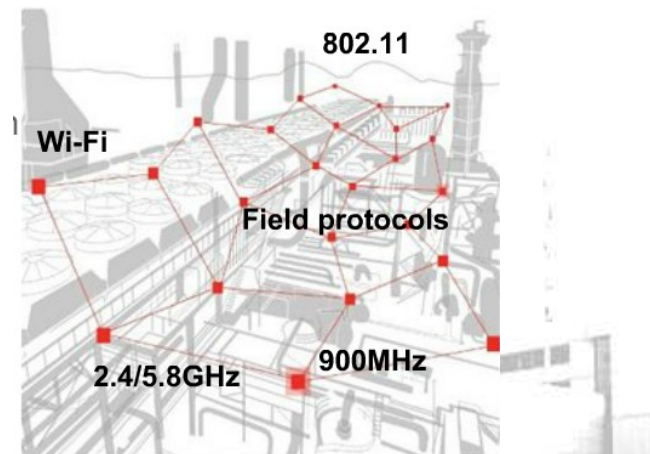
● **Standard Analysis**

- Low Latency Deterministic Networks(LLDN) is specified in IEEE 802.15.4e, which is organized with a superframe structure and using low latency frames.

  - It is for industrial application
  - Deterministic is key point

- All of these exciting industrial wireless standards essentially address the same physical space where wireless can be used for industrial applications.

- It uses determinism scheduling mechanism makes certain nodes communicate in certain slot.

● **Industrial Routing Requirements**

- ● ROLL Working Group has defined application-specific routing requirements for routing protocol in [RFC5673]

- • This RFC provides information on the varying deployment scenarios for such LLNs and how RPL assists in meeting those requirements.

- • Therefore, we suggest some specific metric should be considered, so that

  - – **RPL could become more widely used in industrial application**
  - – **It is good for the RPL used in some applications, such as base on IEEE802.15.4e**

● The Opportunity

- The routing metrics and constraints are specified in [RFC6551], which provides a high degree of flexibility and a set of routing metrics and constraints.

- This document specifies Object-Scheduling Waiting Time as the routing metrics and constraints to be used in path calculation for Low Latency Deterministic Networks.

- The new metrics and constraints we define in this document could be advertised as a metric to optimize the computed path and as a constraint.

- **Definition**

  ◆ **Scheduling waiting time**: The time is used to for a node have to wait to send data to a special node in a period. When the MAC layer schedules the slot time and channel resources of network with TDMA mechanism, each node gets send slots and receive slots.

  ◆ **Determinism:** It is usually meant that access to the control network by a node may be delayed, where t is known. In industrial wireless network, it also means that data is sent and received within the stipulated time.

• Scheduling Waiting Time Object

```
0                               1
0 1 2 3 4 5 6 7 8 9 0 1 2 3
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| (sub-object) .....
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Scheduling Waiting Time Object Body Format

```
0                   1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Scheduling Waiting Time                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
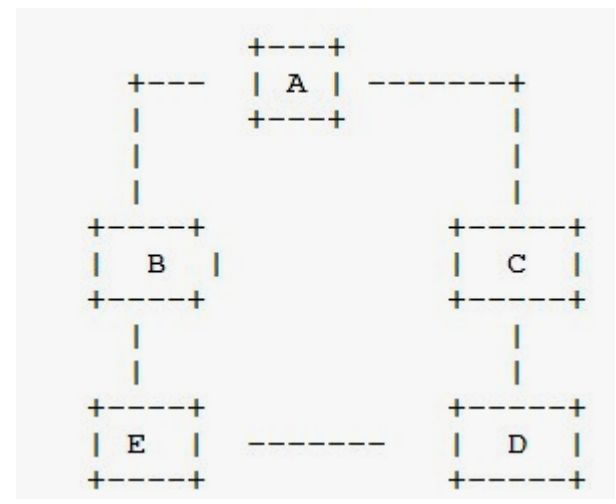
**Scheduling Waiting Time sub-object Format**

- **Mode of Operation**

- The Scheduling Waiting Time may be used as a constraint or a path metric.

  - Scheduling Waiting Time object common header indicates that the provided value relates to a constraint.

  - Scheduling Waiting Time object may be used as an aggregated additive metric where the value is updated along the path to reflect the path Scheduling Waiting Time.

- There is an instance to explain how to use Scheduling Waiting Time object to be as a metric and constraint. The topology of the network is show as Figure.
- There are 15 timeslots in the superframe, which has been allocated to each node. We define them as timeslot 1, timeslot 2 ... timeslot 15. Here, we define a timeslot as 10 ms.
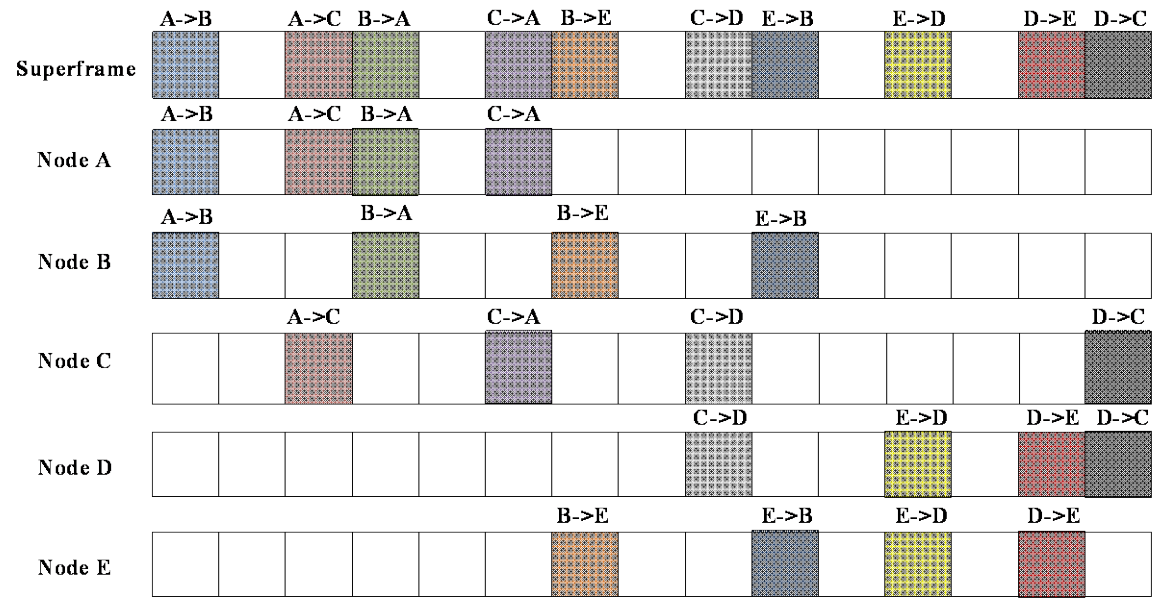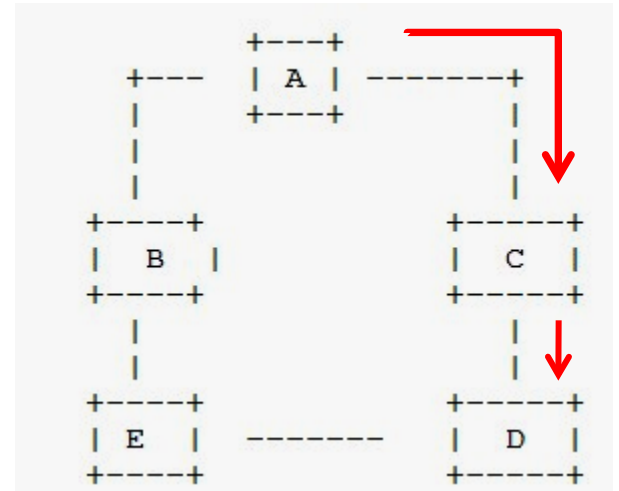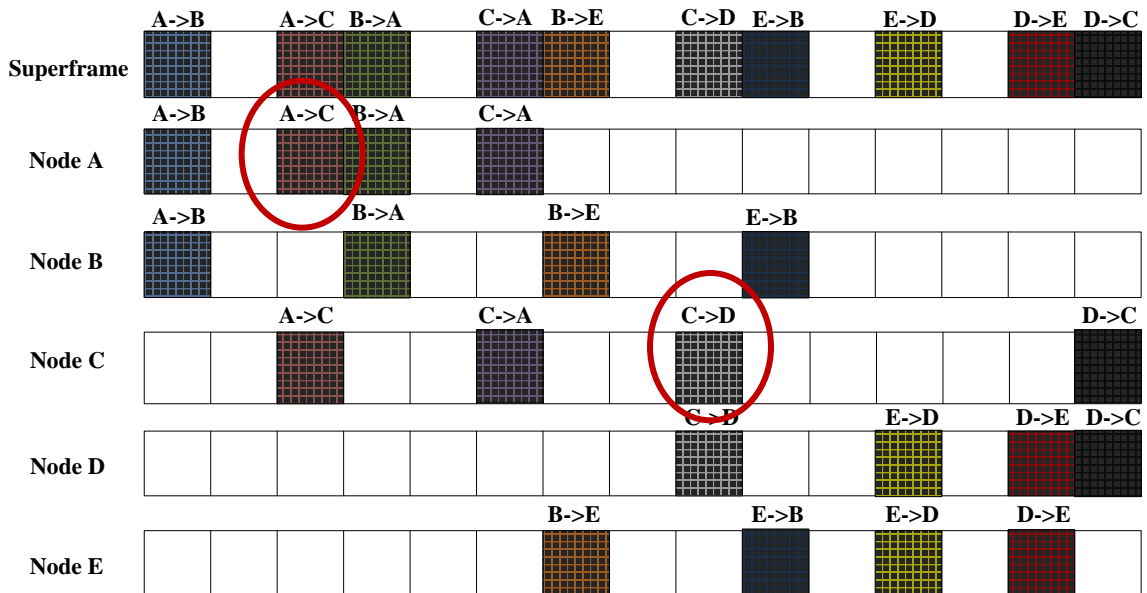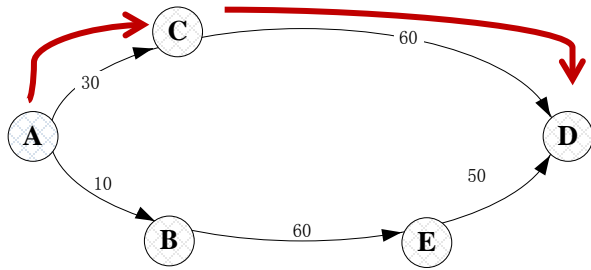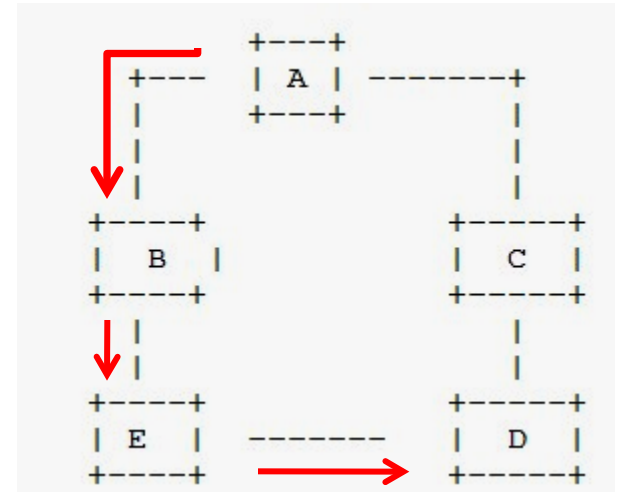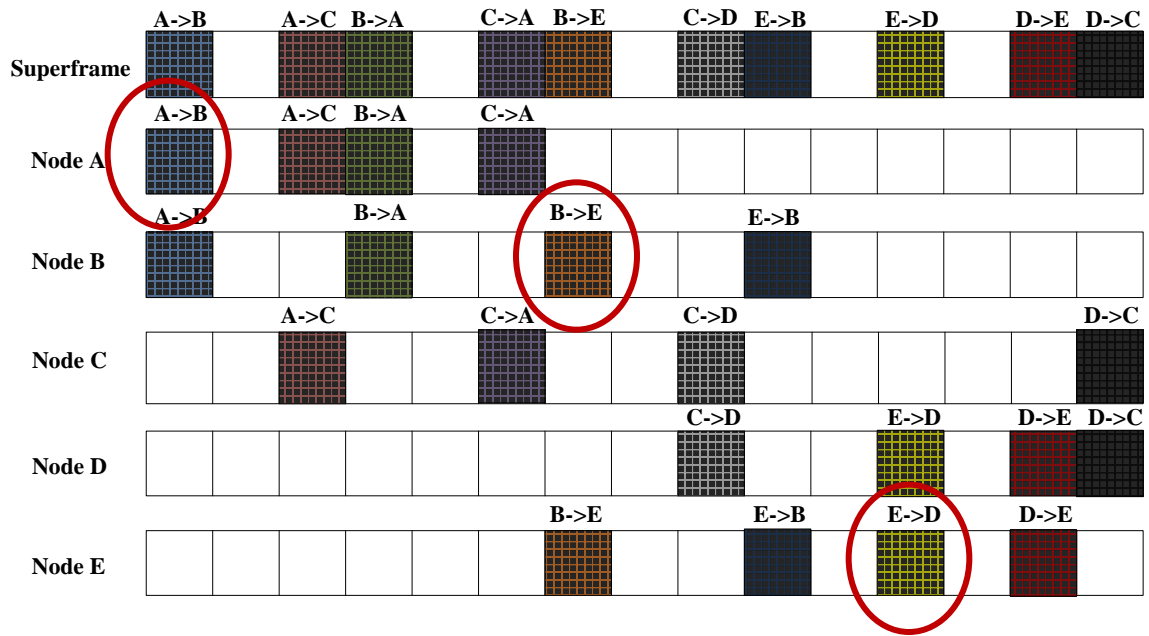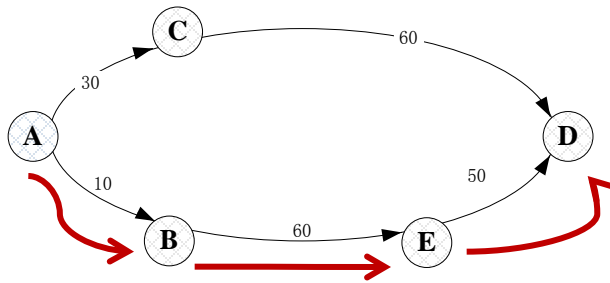
A->C: 3*T$_{slot}$=30ms

C->D: 6*T$_{slot}$=60ms

A->C->D: 90ms

A->B: 1*T$_{slot}$=10ms

B->E: 6*T$_{slot}$=60ms

E->D: 5*T$_{slot}$=50ms

A->B->E->D:120ms

- # IANA Considerations

Value	Meaning	Reference
1	Node State and Attribute	RFC6551
2	Node Energy	RFC6551
3	Hop Count	RFC6551
4	Link Throughput	RFC6551
5	Link Latency	RFC6551
6	Link Quality Level	RFC6551
7	Link ETX	RFC6551
8	Link Color	RFC6551
9	Scheduling Waiting Time	This document

- **Note: It is different from the Link Latency.**

• **Conclusion and Future Work**

• This document defines a new Scheduling Waiting Time Object for RPL to support scheduling mechanism and to meet the industrial requirement of determinism.

• It could be used as one of the multi-metrics and work with the others. When using a dynamic routing metric in LLND, a RPL implementation should use multi-threshold schemes to void spurious and unnecessary routing changes. For the object format structure, the additional field is not added.

• The reserved bit is used. However, the new object needs to be transmitted during the networking stage, which in fact needs extra overhead of 4 bytes.

• While the network scheduling information changes, we need re-send a new value. Otherwise, if network scheduling information does not change, there is no need to send new value.

- **Conclusion and Future Work**

  - Cooperate with other groups (e.g. HCF, WIA-PA, ISA and IEC) to make this a success
    - P802.1Qbu
    - P802.1Qbv
    - SAE AS6802

Thanks !