Deterministic Networking Reading Notes

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The reading materials are available at

`https://github.com/jamesrenxiangyu/Deterministic-Netowrk-Reading-Notes`

Contents

The reading summary mainly follows the structures below. For survey paper and RFC documents:

- What is the paper about.
- What are the key points discussed/introduced in the paper.
- What are the current research issues/directions and why.
- Ideas on existing works.

For research paper:

- What are the key points of the paper.
- What are the advantages.
- What are the disadvantages and why.
- Whether there are improvements.

1 Overview of Deterministic Networks

In this section, the note first summaries several recent works on Deterministic Networks (DetNet), introducing the definition of DetNet, the background knowledge, current research status, and use cases. The overview of DetNet helps to understand DetNet in the big picture. In the mean time, the note will remark on some of the papers regarding the conclusions, ideas, and question.

1.1 Deterministic Networking (DetNet) vs Time Sensitive Networking (TSN) [1] – 2019

The paper mainly summarized the features of IEEE TSN and IETF DetNet, respectively. IEEE TSN was originated from the Audio Video Bridging (AVB) industrial standard, established in IEEE 802.1 standard in 2007, and later extended to the current IEEE TSN. TSN is confined in layer 2, mainly focusing on addressing time synchronization, and bounded latency and zero congestion loss issues. The time synchronization is standardized in IEEE 802.1 AS by sharing time reference network-wide. Several standards were established to address the latter ones, e.g., IEEE 802.1 Qbv, IEEE 802.1 Qbu, and IEEE 802.1 Qch. The reliability issue is addressed by frame replication and elimination in TSN, which was standardized in IEEE 802.1 CB.

On the other hand, the DetNet WG extends the ULL service to layer 3. The goal of DetNet is similar to TSN, i.e., achieve time synchronization, zero congestion loss and high reliability, and high security. It is worth mentioning that DetNet considers not only the delay upper bound but also the lower bound, aiming at smaller jitter. Although DetNet is still under developing, several critical Internet drafts have been proposed in the RFC documents. In this paper, the architecture, data-plane framework, and security are briefly discussed.

Last but not the least, the paper listed several use cases for both TSN and DetNet, respectively. For example, TSN with bounded latency and high-reliability are necessary in 5G scenario, such as helping network slicing and realize the fronthaul connection in Ethernet bridged networks. According to the paper, the future works of TSN focus on how to fit for large-scale network, and thereby, enhance interconnectivity and simplify network management. DetNet, although not standardized yet, is promising in machine-to-machine communication (M2M), and professional audio and video industry (ProAV).

Remark: This is a simple summary of two on-going projects TSN and DetNet. It gives us an overview of their history, features, and current research status.

1.2 Deterministic Networking Problem Statement [2] – 2019

This document briefly introduces the expected outcome of implementing DetNet, the possible solutions and their corresponding difficulties. As it is written in the literature, DetNet aims to establish a multip-hop path over IP or MPLS network for particular flow that satisfies the given QoS requirements (low latency and jitter, zero congestion loss, high delivery ratio, etc.) regardless other flows the in network. Some specific features of DetNet are mentioned.

- Time synchronization.
- Support deterministic packet flows with following features:
  - Can be either unicast or multicast.
  - Absolute guarantees of minimum and maximum end-to-end latency. Maybe tight jitter.
  - A packet loss ratio beyond the classical range for a particular medium, in the range of 10^{-9} to 10^{-12} or better on Ethernet and on the order of 10^{-5} in wireless sensor mesh networks.
  - High resource usage efficiency. Absorb more than half of the network's available bandwidth.
  - Free of network-imposed delay, such as throttling, congestion feedback.
- Multiple methods of controlling critical packet transmission, such as scheduling, shaping, limiting, at each hop.
- Robust defenses against misbehaving hosts, routers, or bridges, in both the data plane and the control plane. Guarantees no impact from other flows.
- One or more methods on resource reservations.

The literature mainly discussed the possible solutions or requirements from the following perspectives.

- Supported topology. In any case, routers and switches in between should not need to be aware of whether the path is end to end or a tunnel.
- Flow Characterization. Before a path is established for a critical flow, the expression of the flow characteristics, and how network can serves them must be specified.

- Centralized path computation and installation. To enable a centralized model, DetNet should produce a description of the high-level interaction and data models based on Path Computation Element (PCE).
- Distributed Path Setup. One possible solution is to build on RSVP-TE.
- Duplicated Data Format. A small number of packet formats and supporting protocols are required to support packet duplication and elimination on non-congruent paths.
- Security. The time of delivery of a packet can be very important due to the virtualization of networks over same infrastructure. Security of DetNet must cover the protection of signaling protocol, the authentication and authorization of the controlling nodes, identification and shaping of the flows, and isolation of flows from leakage.

Remarks: Our recent work DSRBP matches most of the features mentioned in the literature. Some extra considerations for DSRBP may include: (1) guarantee both maximum and minimum latency (current work guarantees maximum delay only). (2) standardize flow/packet characterization. (3) Incorporate packet duplication and elimination to satisfy ultra high reliability.

1.3 Deterministic Networking Architecture

1.4 Deterministic Networking Use Cases

2 Appendix A

References

[1] X. Yang, D. Scholz, and M. Helm, "Deterministic networking (detnet) vs time sensitive networking (tsn)," *Network*, vol. 79, 2019.

[2] N. Finn and P. Thubert, "Deterministic networking problem statement," *draft-finn-detnet-problem-statement-05 (work in progress)*, 2016.