        Operations, Administration and Maintenance (OAM) features for RAW
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Abstract

   The wireless medium presents significant specific challenges to
   achieve properties similar to those of wired deterministic networks.
   At the same time, a number of use cases cannot be solved with wires
   and justify the extra effort of going wireless. This document
   presents some of these use-cases.

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1. Introduction

RAW (Reliable and Available Wireless) is an effort to provide deterministic behavior over a network that includes a wireless physical layer. Enabling the wireless communication reliable and available is even more challenging than it is with wires, due to the numerous causes of loss in transmission that add up to the congestion losses and the delays caused by overbooked shared resources. To provide quality of service along a multihop path that is composed of wired and wireless hops, additional methods needs to be considered to leverage the potential lossy wireless communication.

Traceability belongs to Operations, Administration, and Maintenance (OAM) which is the toolset for fault detection and isolation, and for performance measurement. More can be found on OAM Tools in .

The main purpose of this document is to details the requirements of the OAM features recommended to construct a predictable communication infrastructure on top of a collection of wireless networks. In particular, we expect to provide packet loss evaluation, self-testing and automated adaptation to enable trade-offs between resilience and energy consumption.

This document describes the benefits, problems, and trade-offs for using OAM in wireless networks to provide availability and predictability.

In this document, the term OAM will be used according to its definition specified in [RFC6291]. We expect to implement an OAM framework in RAW networks to maintain a real-time view of the network infrastructure, and its ability to respect the Service Level Agreements (delay, reliability) assigned to each data flow.

1.1. Terminology

o OAM entity: a data flow to be controled;

o OAM end-devices: the source or destination of a data flow;

o defect: a temporary change in the network characteristics (e.g.
   link quality degradation because of temporary external
   interference, a mobile obstacle)

o fault: a definite change which may affect the network performance,
   e.g. a node runs out of energy,

2. OAM to provision appropriately the resources

RAW networks expect to make the communications predictable on top of
a wireless network infrastructure. Most critical applications will
define a Service Level Agreeemnt to respect for the data flows it
generates. Thus, the wireless networks have to be dimensionned to
respect these SLAs.

To respect strict guarantees, RAW relies on a PCE which has to
schedule the transmissions in the different wireless networks. Thus,
resources have to be provisionned to handle any defect. OAM
represents the core of the overprovisonning process, and maintains
the network operational by updating the schedule dynmically.

Fault-tolerance also assumes that multiple path have to be
provisionned so that an end-to-end circuit keeps on existing whatever
the conditions. OAM is in charge of controling the replication/
process

To be energy-efficient, reserving some dedicated out-of-band
resources for OAM seems ireealistic, and only in-band solutions are
considered here.

3. Operation

RAW expects to operate fault-tolerant networks. Thus, we need
mechanisms able to detect faults, before they impact the network
performance.

We make a distinction between the two following complementary
mechanisms:

o Detection: the network detects that a fault occured, i.e. the
   network has deviated from its expected behavior. While the
   network must report an alarm, the cause may not be identified

precisely. For instance, the end-to-end reliability has decreased
significantly, or a buffer overflow occurs;

o Identification: the network has isolated and identified the cause
   of the fault. For instance, the quality of a specific link has
   decreased, requiring more retransmissions, or the level of
   external interference has locally increased.

These two-steps identification is required since RAW expects to rely
on wireless networks. Thus, we have to minimize the amount of
statistics / measurements to exchange:

o energy efficiency: low-power devices have to limit the volume of
   monitoring information since every bit consumes energy.

o bandwidth: wireless networks exhibit a bandwidth significantly
   lower than wired, best-effort networks.

Thus, localized and centralized mechanisms have to be combined
together, and additionnal control packets have to be triggered only
after a fault detection.

[4]. Administration

To take proper decisions, the network has to expose a collection of
metrics, including:

o Packet losses: the time-window average and maximum values of the
   number of packet losses has to be measured. Many critical
   applications stop to work if a few consecutive packets are
   dropped;

o Received Signal Strength Indicator (RSSI) is a very common metric
   in wireless to denote the link quality. The radio chipset is in
   charge of translating a received signal strngth into a normalized
   quality indicator;

o Delay: the time elapsed between a packet generation / enqueuing
   and its reception by the next hop;

o Buffer occupancy: the number of packets present in the buffer, for
   each the existing flows.

These metrics should be collected:

o per virtual circuit to measure the end-to-end performance for a
   given flow. Each of the paths has to be isolated in multipath
   strategies;

o   per radio channel to measure e.g. the level of external
    interference, and to be able to apply counter-measures (e.g.
    blacklisting)

o   per device to detect misbehaving node, when it relays the packets
    of several flows.

4.1. Worst-case constraint

RAW aims to enable real-time communications on top of an
heterogeneous architecture. Since wireless networks are known to be
lossy, RAW has to implement strategies to improve the reliability on
top of unreliable links. Hybrid Automatic Repeat reQuest (ARQ) has
typically to enable retransmissions based on the end-to-end
reliability and latency requirements.

To take correct decisions, the controller needs to know the
distribution of packet losses for each flow, and for each hop of the
paths. In other words, average end-to-end statistics are not enough.
They must allow the controller to predict the worst-case.

4.2. Energy efficiency constraint

RAW targets also low-power wireless networks, where energy represents
a key constraint. Thus, we have to cake care of the energy and
bandwidth consumption. The following techniques aim to reduce the
cost of such maintenance:

   piggybacking: some control information has inserted in the data
   packets if they don't fragment the packet (i.e. the MTU is not
   exceeded). Information Elements represent a standardized way to
   handle such information;

   flags/fields: we have to set-up flags in the packets to monitor to
   be able to monitor them accurately. A sequence number field may
   help to detect packet losses. Similarly, path inference tools
   such as [ipath] insert additionnal information in the headers to
   identify the path followed by a packet a posteriori.

5. Maintenance

RAW needs to implement a self-healing and self-optimization approach.
The network must continuously retrieve the state of the network, to
judge about the relevance of a reconfiguration, quantifying:

   the cost of the sub-optimality: resources may not be used
   optimally (e.g. a better path exists);

the reconfiguration cost: the controller needs to trigger some
reconfigurations. For this transient period, resources may be
twice reserved, control packets have to be transmitted.

Thus, reconfiguration may only be triggered if the gain is
significant.

Since RAW expects to support real-time flows, we have to soft-
reconfiguration, where the novel ressources are reserved before the
ancient ones are released. Some mechanisms have to be proposed so
that packets are forwarded through the novel track only when the
resources are ready to be used, while maintaining the global state
consistent (no packet re-ordering, duplication, etc.)

In particular, RAW has to support the following modifications:

patching a schedule, relocating some radion resources (radio
channel, timeslots);

a device can be reset (e.g. firmware upgrade) safely, all the
flows being forwarded temporarly through alternative paths;

a better path (delay, reliability, energy consumption) has been
identified.

6. Informative References

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