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Required path properties for applying path aware networking in
integrated space-terrestrial networks
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Abstract

Integrated space-terrestrial networks are heterogeneous networks with various path characteristic, and usually belong to different administrative domains. Therefore integrated space-terrestrial networks can be seen as a use case of path-aware networking. This memo introduces requirements on path properties when applying path-aware-network in integrated space-terrestrial networks.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [[RFC2119](#)].

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[1.](#) Introduction

In the integrated space-terrestrial networks, endpoint is capable to access space networks, mobile networks, and fixed networks. These heterogeneous networks have essential difference on characteristics and come from different service providers, which makes it difficult to carry out unified management and control. Furthermore, different with ground networks, the quality of links in space is fluctuating, the network topology changes dynamically, and the resources of space node is limited. It is necessary to come out a system to release the burden of networks(especially space nodes with limited resource) and leaving the complex function to endpoint. In other words, the path-aware network may help to cope with the dynamics of this kind of network.

According to the definition of [[RFC5136](#)], a path is a series of links that connect a series of nodes from the source node to destination. The properties of path can be seen from the overall point of view, or decomposed into node properties and link properties. Corresponding

granular path awareness can be performed in the basis of the capability of the endpoint and/or the required quality of service. This memo will describe the required path properties from different granularity in integrated space-terrestrial networks.

[2.](#) Terminology and Abbreviation

Integrated space-terrestrial Networks(ISTN): A network system that comprehensively utilizes a variety of communication network technologies including space networks and terrestrial networks to achieve global coverage. The integrated system includes ground segment and space segment. The ground segment includes terrestrial network nodes such as ground stations, terminals, servers controllers and terrestrial links such as cable, fiber. Space segment includes space node such as satellites and space links such as laser and radio.

[3.](#) Path properties

The path properties describe the overall properties of the whole path from an end-to-end perspective.

Space and ground networks share some common properties, but due to the essential differences between the space network and the terrestrial network on characteristics such as mobility, link stability, resources etc., some additional properties are required to support path selection at the endpoint.

Common path properties

1. Properties in path
properties[I-D.irtf-panrg-path-properties],such as one way delay and one way packet loss.

Additional path properties in space

1.Available time: path available time; due to the topological dynamics of the space link, the path in the world-ground integrated network is not always available. Therefore, it is necessary to set an available time for each path;

[4.](#) Fine granular properties

In addition to the fluctuating latency, and bandwidth, the complex space environment will lead to unpredictable wireless link disconnection. The mobility of space nodes will lead to periodic dynamic topology change. Therefore, the performance of the path changes more frequently, and the fine granular properties can help the integrated space-terrestrial networks to quickly locate unpredictable faults and find the optimal alternative link instead of discarding the entire path. For example, path properties can be decomposed into node properties and link properties.

[4.1.](#) node properties

Common properties of nodes

1. Node computing resources: computing resources available on ground nodes/space nodes. When the available computing resource is less, it indicates that the node is heavy-loaded, and the path that contains the node should be avoided when selecting a path.

2. Node storage resources: available storage resources of ground nodes/space nodes.

Additional node properties in space

1. Node power: This is actually the most important property of space, because the energy of satellite in space comes from solar panels, which make the node energy fluctuating with time. If the power of the satellite node is not sufficient to support additional computing/communication functions, the satellite node is not available; it can be simply set to 0/1 to indicate whether the node supports additional computing/communication functions.

2. Available interfaces of the node. The interface that can be used to establish a link, it may contain a set of information indicating the direction of interface and available next hop. This property can be used to derive the topology information. The specific link status is excluded and needs to query the link properties described below.

3. The future available interfaces of the node. The movement of

satellite nodes is periodic. Periodicity can be used to predict the topology in the future to help make routing decisions. This property can be sent in different manners, depending on the mechanism the system used to deal with the network mobility. This property can be sent in each time slot if the system use snapshot. Or to reduce the interaction cost, event triggered property notification can be used, that is the notification only executes when the available interfaces changes due to unexpected event.

[4.2.](#) Link properties

Common link properties

1.Propagation delay:When a data packet propagates from the source node to the destination node, the time required for the transmission from the beginning to the end of the link is the propagation delay. Data packets are propagated at the propagation rate of the link, and its rate depends on the physical medium of the link. The propagation delay is equal to the ratio of the distance between the nodes and the

propagation rate. As the distance between the nodes changes as space node moves, the delay changes as well.

2.Link media: the link media can be laser/cable/radio etc., and the different media can have different priority and cost, which should be used to do the path selection decision.

3.Quality of link: This property can be indicated by bit error rate or packet loss rate, depending on the network system.

Additional link properties in space

1. Available time: When the nodes at both ends of a link are constantly moving relative to each other, the link may be unavailable because the nodes move out of mutual visible area. Therefore, it is necessary to know the available time of the link.

2. Link status: different from bit error rate, this property indicates the state of link, for example, when the link is temporarily unavailable due to space environment, it can be set in leave and; when the link is unavailable due to mobility, it can be set to down . The link state information may not come from space node

itself but from ground measurement and control station.

[5.](#) Summary

Integrated space-terrestrial Networks can take advantage of the PAN and can be seen as a typical use cases. When PAN is introduced into ISTN, it will have some different requirements on the path properties, and this memo study the first question in [[I-D.irtf-panrg-questions](#)] by list and explain some potential path properties.

[6.](#) Security Considerations

It should be noticed that under the Integrated space-terrestrial Networks background, the topology information comes from different operators, they may not willing to expose their network information to other operators or other 3rd parties, so it is crucial to find a way to supply the information to end user while not expose to others.

[7.](#) IANA Considerations

This document has no requests to IANA.

[8.](#) Normative References

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