Carrier Class Transport Network Technologies: Summary of Initial Research

This document is a summary of the JRA1 Task 1 Carrier Class Transport Network Technologies deliverable [DJ1.1.1], which presents the initial findings of a study of different transport network technologies that meet the criteria of Carrier Class and that fall within the scope of JRA1 T1 as a research activity, i.e. they are either new technologies, or new developments in well-established technologies. It defines Carrier Class Transport Network Technologies (CCTNTs) and establishes their background: their evolution from Plesio-synchronous Digital Hierarchy (PDH) through Synchronous Optical Networking / Synchronous Digital Hierarchy (SONET/SDH) and Optical Transport Networking (OTN) to next-generation networking; the challenge presented by data traffic and by the National Research and Education Networks' (NRENs') environment and experience; the benefits and motivations for using CCTNT; the key concepts and requirements – data traffic, functionality (especially Quality of Service (QoS) and control plane protocols such as Generalised Multi-Protocol Label Switching (GMPLS)), research networking, environmental, cost – that qualify a transport network technology as Carrier Class. It then outlines the ways in which a set of representative technologies deliver those requirements, and reports on their standardisation status.

Definition

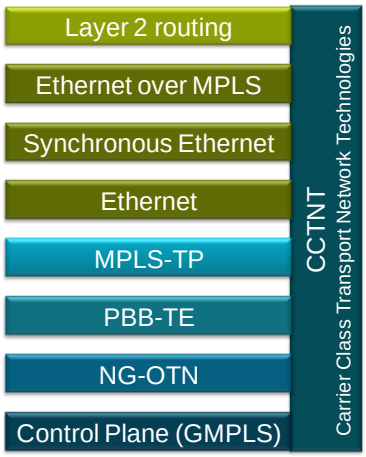
JRA1 T1 has defined CCTNTs as technologies designed to provide transport for network services and protocols. Carrier Class denotes that the technologies are extremely reliable, support a wide range of speeds up to the current industry maximum, and are well-tested and proven in their capabilities.

A transport network technology must meet the following criteria to qualify as a CCTNT:

- Effectively support diverse types of traffic such as the elastic traffic of data applications and time-sensitive multimedia traffic.
- Effectively support all popular customer services such as Internet access, Virtual Private Networks (VPNs), Voice over IP (VoIP), IPTV and others.
- Be manageable by providing diverse and feature-rich Operations, Administration and Management (OAM) functionality.
- Be reliable by providing resilience and fast restoration for transport connections.
- Be scalable to support numerous customer connections through a carrier network.
- Be able to provide Quality of Service (QoS) and bandwidth guarantees when necessary.
- Provide separation of customer and provider networks in terms of operation and configuration parameters such as address spaces, connection IDs and others.

- Be cost-effective. This is a major requirement for service providers. Network costs are extremely high and a good argument for service providers to change their legacy technologies is the ability to provide better and more flexible services at the same or, if possible, lower cost.
- Deliver high bandwidth and performance up to the current industry limit (i.e. up to 40 G today and up to 100 G in the nearest future).
- Conform to the appropriate standards.
- Be multi-protocol. A CCTNT should be capable of transporting any kind of customer traffic and so should support different if not all existing protocols.

Taking into account these criteria, the technologies considered are the following:



Next-Generation OTN (NG-OTN)

NG-OTN is the newest concept of converged core transport architecture, designed more for Ethernet than for telecommunications traffic, and formed of a collection of standards initially written a decade ago – but being completely renewed by the ITU-T, with input from other standards bodies. The challenge is to address the delay sensitivities of data networking whilst utilising an OAM-rich architecture – all at ultra-high capacity. In these ways, NG-OTN symbolises not only new technology and architectural design, but also an entirely new approach to transport networking.

DJ1.1.1 provides a detailed study of OTN, covering its origins and evolution; architecture and features, particularly those that qualify it as a CCTNT; standardisation; and the ongoing work of ITU-T Study Group 15 (SG15) to develop this technology, make it more flexible and realise its potential.

See also OTN and NG-OTN overview document [OTN].

Ethernet

Ethernet as a transport technology has existed for many years. However, it was lacking some of the functionality necessary to qualify as Carrier Class. DJ1.1.1 describes recent developments in the Ethernet

standards that address some of these deficiencies, namely Ethernet OAM, Ethernet QoS and high-speed Ethernet (40 GE and 100 GE).

Layer 2 Routing

The term Layer 2 Routing denotes routing protocols that are designed specifically for Layer 2 devices such as Ethernet switches. The design principles of well-known Layer 3 routing protocols (L3 being the network layer with which routing protocols are usually associated but to which they are not, in fact, exclusively bound) such as Open Shortest Path First (OSPF) or Intermediate System to Intermediate System (IS-IS) do not require major changes to work with Ethernet switches. However, the details of the protocol, for example, the format of addresses carried in routing protocol advertisements, do have to change. There are currently several initiatives that aim to develop the Layer 2 Routing protocol:

- Provider Link State Bridges (PLSB): the proprietary routing protocol from Nortel.
- Shortest Path Bridging (SPB): from the IEEE. There are two different flavours of SPB: SPB VID (SPBV) and SPB MAC (SPBM).
- Transparent Interconnection of Lots of Links (TRILL): from the IETF.

DJ1.1.1 focuses on SPBM, since it is the only protocol aimed at Provider Backbone Bridges (PBB) / Provider Backbone Bridge Traffic Engineering (PBB-TE) technologies, which have many more features of a Carrier Class network transport technology than plain Ethernet, at which SPBV and TRILL are aimed. It describes the design principles of SPBM, briefly considers each of the focus areas, including ongoing standardisation by the IEEE and offers observations on maturity and competition.

Synchronous Ethernet

Synchronous Ethernet is a new standard defined by ITU-T for the distribution of accurate frequency over Ethernet ports and links by the very precise control of the bit rate of an Ethernet link. DJ1.1.1 provides an introduction to Synchronous Ethernet, covering ITU-T terminology, frequency synchronisation versus time synchronisation, the concept and uses of accurate frequency, benefits and possible problems as well as features. It also explains why this technology has been presented as a CCTNT and not just as a feature of traditional Ethernet. Its status as a CCTNT is, however, still a subject of debate.

Ethernet over Multi-Protocol Label Switching (EoMPLS)

Ethernet over IP/MPLS (Internet Protocol/Multi-Protocol Label Switching) is one of the technologies that can be used to transport Ethernet frames over a provider's backbone network. Although MPLS is said to be complex, it is also popular in big providers' networks and over the years of its deployment it has proved its reliability and scalability. DJ1.1.1 provides information on developments that have occurred during recent years, particularly those defined by the Metro Ethernet Forum (MEF), in order to turn EoMPLS into a CCTNT, including the

implementation of Virtual Private Wire Service (VPWS), Virtual Private LAN Service (VPLS) and Virtual Private Multicast Service (VPMS), improvements in OAM functionality, protection and restoration, and multicasting.

Multi-Protocol Label Switching Transport Profile (MPLS-TP)

MPLS-TP is a profile of IP/MPLS designed to meet transport network operational requirements. It takes key elements from IP/MPLS such as MPLS / Pseudowire Emulation Edge to Edge (PWE3) architecture and forwarding mechanisms, and, optionally, GMPLS control plane, and provides additional functionality such as performance monitoring, OAM, Tandem Connection Monitoring (TCM), protection switching and ring protection. DJ1.1.1 presents the background to MPLS-TP, including its evolution from its initial form to the ITU-T's development of T-MPLS, describes its characteristics and requirements, architecture and main capabilities, and tries to provide a snapshot of the ongoing standardisation work being carried out by a joint ITU-T and IETF working team.

Provider Backbone Bridge Traffic Engineering (PBB-TE)

Provider Backbone Bridge Traffic Engineering (PBB-TE) is the third (and latest) standard developed by the IEEE with the aim of giving providers a Layer 2 carrier-grade transport based on classical Ethernet, a.k.a. Carrier Ethernet Transport (CET). The first two technologies of the CET family are Provider Bridges (PB) and Provider Backbone Bridges (PBB). As PBB-TE re-uses some features of PB and especially of PBB, DJ1.1.1 provides a brief description of these technologies before describing the features, capabilities and limitations of PBB-TE itself, and offering observations on its maturity, competitors and applicability.

Industry Focus Areas

One of the current focus areas for the parties involved in developing these technologies is the implementation of features that were present in legacy technologies but which are missing, either completely or partly, from the most recent technologies. Such features include OAM functionality, protection and restoration mechanisms, and the possibility to operate with or without the control plane. Other focus areas are cost-effectiveness, environmental impact, and the integration of all the technologies within seamless network architecture, there being a marked design tendency towards convergence, cross-layer capability and flat networks. For these reasons, the study's assessment of most of the technologies has focused on the following areas. (Some of the technologies did not fit precisely into this structure because of their different features, degree of maturity, and amount of available documentation or extent of standardisation.)

- Features:
  - Quality of Service (QoS).
  - Protection and restoration.
  - Operations, Administration and Maintenance (OAM).
  - Multicasting.
  - Control plane protocols (including GMPLS).

    - Multi-domain services.
    - Standards.
    - Scalability and manageability.
- Applications.
- Cost-effectiveness.
- Standardisation.

Summary

DJ1.1.1 ends with a summary comparison of the CCTNTs' functionality, and concludes that, in the opinion of the JRA1 Task 1 team, all of the technologies described in the document are of potential interest to the research networking community. It is the intention that the report [DJ1.1.1] will help the community to understand the strengths and weaknesses of each one. DJ1.1.1 does not single out any of the technologies as "the best", does not create any ranking of the available technologies, and does not provide any simple tips for selecting a technology. Instead, it provides information about them all and allows the reader to decide which one is the best for their network. The question of which technology is the most suitable for future networks is not addressed as the answer depends on each NREN's particular needs, which in turn depend on many factors such as type of organisation, type of services delivered, skill set of the operations staff, legacy network and services, etc. However, it is expected that this report [DJ1.1.1] will provide the information necessary to help organisations select the most appropriate technology, given their respective needs.

The study focuses on new technologies, or new aspects and improvements of mature technologies, many of which are still in the process of being developed and standardised. It is likely that some of the information it presents will change in future, or new information become available that could have been of major relevance to the study. DJ1.1.1 therefore provides only a snapshot of the current situation, with indications of where the technologies are heading; it is anticipated that any additions or changes will be reflected in JRA1 Task 1's future work.

References

[DJ1.1.1] GN3-09-224 “Deliverable DJ1.1.1: Transport Network Technologies Study”, 26-05-2010, Authors: Alberto Colmenero (NORDUnet), Rebecca Corn (DANTE), Marcin Garstka (PIONIER), Jac Kloots (SURFnet), Victor Olifer (JANET), Jan Radil (CESNET), Krzysztof Stanecki (PIONIER), Sue Tyley (DANTE) http://www.geant.net/Media_Centre/Media_Library/Media%20Library/GN3-09-224-DJ1-1-1v1-0_Transport_Network_Technologies_Study_Read_Only.doc

[OTN] OTN and NG-OTN: Overview https://www.geant.net/Research/Future_Network_Research/Documents/OTN_and_NG-OTN_Overview.pdf

Glossary

CCTNT	Carrier Class Transport Network Technologies
CET	Carrier Ethernet Transport
EoMPLS	Ethernet over Multi-Protocol Label Switching
GMPLS	Generalised Multi-Protocol Label Switching
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
IS-IS	Intermediate System to Intermediate System
ITU-T	International Telecommunication Union – Telecommunication Standardisation Sector
MEF	Metro Ethernet Forum
MPLS	Multi-Protocol Label Switching
MPLS-TP	Transport Profile
NG-OTN	Next-Generation Optical Transport Networking
NREN	National Research and Education Network
OAM	Operations, Administration and Management
OSPF	Open Shortest Path First
OTN	Optical Transport Networking
PB	Provider Bridges
PBB	Provider Backbone Bridges
PBB-TE	Provider Backbone Bridge Traffic Engineering
PBT	Provider Backbone Transport
PDH	Plesio-synchronous Digital Hierarchy
PLSB	Provider Link State Bridges
PWE3	Pseudowire Emulation Edge to Edge
QoS	Quality of Service
SDH	Synchronous Digital Hierarchy
SG15	ITU-T Study Group 15
SONET	Synchronous Optical Networking
SPB	Shortest Path Bridging
SPBM	SPB MAC
SPBV	SPB VID
TCM	Tandem Connection Monitoring
T-MPLS	Transport Multi-Protocol Label Switching
TRILL	Transparent Interconnection of Lots of Links
VoIP	Voice over IP
VPLS	Virtual Private LAN Service
VPMS	Virtual Private Multicast Service
VPN	Virtual Private Networks
VPWS	Virtual Private Wire Service