RENA Transmission System Architecture

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Abstract

The underlying concept of the resonant communication network architecture (RENA) is to achieve safe, secure, and simple communication. This article examines the architecture of its transmission system, which consists of user, access, and core networks, in some detail from the standpoints of quality control, enhanced reliability, and cost-effectiveness.

1. RENA transmission system

The transmission system of the resonant communication network architecture (RENA) primarily refers to the data transmission and quality control capabilities in RENA-based networks [1], [2] and consists of user, access, and core networks. Here we describe the architecture of the transmission system in some detail focusing primarily on how the system handles the delivery of Internet protocol (IP) packets.

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2. User network

This is the network that is directly accessed by the user. Quality of service (QoS) and reliability are assured by interconnection with the carrier-side network, so its primary requirement is the ability to provide a diverse range of intuitive, user-friendly services. To take full advantage of these capabilities, a home gateway (HGW) with the following capabilities is required (Fig. 1).

• Quality control (bandwidth reservation and priority

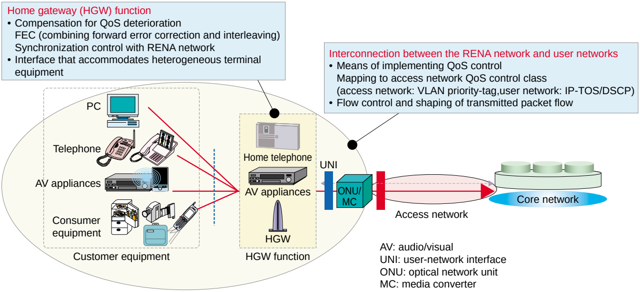

Fig. 1. User network architecture and transmission system functions.

control): The type of service of the transmitted packets is identified (e.g., VoIP (Voice over IP), CDN (Contents Delivery Network), or VPN (Virtual Private Network)), and depending on the result, information is assigned regarding the IP packet service requirements of the carrier-side network: IP-TOS (type of service) and DSCP (Diffserv code point) values (IPv4 and IPv6 Layer 3 priority, respectively) and VLAN (virtual LAN) priority tag (Layer 2 priority). The assignment here of a Layer 2 priority determines the QoS at the access network, as described below. In addition, output packet flow control and shaping functions in accordance with reserved bandwidth are also required.

- Quality loss compensation: Forward error correction (FEC) that combines error correction with interleaving is used to compensate for packets lost in transmission, and the lost packets are retransmitted. The rate at which packets are read out of the receive buffer is also controlled and synchronized with the carrier side.
- Diverse interfaces: In addition to the interface with the carrier side, numerous other interfaces are provided for sending data to the diverse terminal equipment of users.

3. Access network

The access network provides the link between the user network and a core network edge router or an optical video content delivery network. It is independent of the core network and cost-effectively delivers diverse kinds of service data with appropriate QoS control. For broadband-capable systems like RENA, there is a diverse range of access systems suited to different user and area attributes that can be economically deployed including media converters, passive optical networks, and wavelength division multiplexing (WDM), fixed wireless access, and wireless LAN (local area network) systems. Let us mention the types of areas where these options can be most cost-effectively deployed:

- Media converters: A cost-effective approach for situations in which users fully occupy the bandwidth (e.g., users generate a high traffic volume); suitable for business users, concentrated housing or condominium developments, or areas where there is little demand.
- Passive optical networks: An economical solution in areas where users share bandwidth and equipment, and thus there is high demand; viable where there is a large base of users and high demand.
- WDM access: This is a cost-effective approach in situations where users occupy the bandwidth and there is highly concentrated demand. While this option is still more costly than a passive optical network, it is nevertheless an economical solution for business users, densely concentrated residential developments, and other areas of high demand.
- Fixed wireless access: This provides a way to extend broadband to areas that are currently not served by optical facilities.
- Wireless LAN: This option is used to provide access to hot spots and other mobile destinations.

Quality control in the access network is implemented based on the following considerations (Fig. 2):

① The various protocols used by user and core networks are transmitted transparently, but consider-

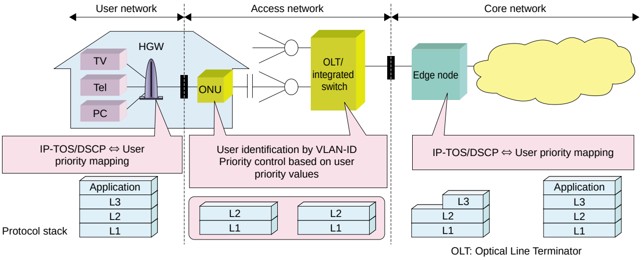

Fig. 2. Transmission system QoS control functions.

ing that the access network interface must be independent of these protocols and possess a high degree of freedom, it is implemented in Layer 2.

② For the packet priority identifier, the unique VLAN-priority-tag identifier is used in Layer 2.

③ Quality control for the access network is implemented in Layer 2 and that for the core network in Layer 3, so linkage between user and core networks is achieved by converting IP-TOS/DSCP values to VLAN-UserPriority values, and vice versa.

4. Core network

The increasing penetration of the Internet coupled with a growing number of people accessing broadband services by ADSL (asynchronous digital subscriber line) and cable modems has caused the volume of network traffic to skyrocket, increasing some ten-fold in just eighteen months. We can safely project that this trend will only intensify as the number of users and the bandwidth usage increases with the deployment of more broadband access lines, enhancement and expansion of content delivery capabilities, and availability of better quality services exploiting the features of broadband. Networks supported by RENA must therefore not only provide a diverse range of high-quality broadband services, but in their role as the basic public infrastructure for the foreseeable future, they must also provide a very high standard of reliability and enormous excess capacity with cost efficiency.

To provide a spectrum of QoS options ranging from best effort to high-quality leased line class services and flexible reliability, the core network must provide *quality control capabilities* to ensure the quality of services delivered end-to-end across the network and *reliability capabilities* that can protect the network and minimize adverse effects on services of any problems that might arise. Just as importantly, the network—consisting of transmission lines and nodes—must provide enormous excess capacity in anticipation of rapidly increasing traffic volumes, and it must do so at low cost. NTT is now responding to these exacting demands with the development and deployment of optical technologies (with emphasis focused on large-capacity WDM technology exploiting optical wavelength and optical cross connect (OXC) technology) and multilayer integration technology that delivers traffic very efficiently in cooperation with the IP layer while taking full advantage of the huge capacity enabled by optical technology.

5. Core network quality control and enhanced reliability

The multiprotocol label switching (MPLS) standard is now receiving much attention as an effective means of achieving quality control and enhanced reliability. MPLS adds a label containing routing information to each packet at a network edge node, then delivers the packets from beginning to end of a label switched path (LSP) over the specified network, an approach that is currently used primarily on IP-VPNs to ensure privacy over the Internet. The packets are forwarded at each core node over the path specified in the label information. Note that not just IP packets but all kinds of packets can be mapped to an LSP at an edge node, and sent across the same network based on the routing information contained in the label. A range of service quality classes can be applied to various end-to-end services on the MPLS-enabled network by combining packet priority delivery control, flow minimum guaranteed bandwidth control, and other QoS control functions. For example, any of a range of service classes can be set for each LSP including Expedited Forwarding (EF), the highest priority class, Assured Forwarding (AF), the lowest class in which bandwidth is guaranteed, and Best Effort (BE), in which QoS is not guaranteed. As illustrated in Fig. 3, the minimum bandwidth on each LSP and the priority of packets flowing across those paths can be controlled by traffic policing at the initial node (filtering based on bandwidth assigned to each flow and colors attached to each packet to show the delivery priority of the data) and Diffserv-based queue control at all the intermediate nodes on the network (EF class fixed priority and AF class read-out priority control). Priority control and minimum bandwidth guarantee are thereby achieved for each LSP. Reliability has also been significantly improved. On existing IP networks, route switching times ranging from several seconds to several tens of seconds have been required when core network equipment fails, but now faster switching times equivalent to protection switching-enabled leased lines have been achieved between LSPs on MPLS networks.

6. Core network multilayer pass-through technology

If the prevailing trend for IP-based services continues, we can anticipate the need for core nodes with terabit-per-second-class capacity in just a few years. One highly promising approach for handling such

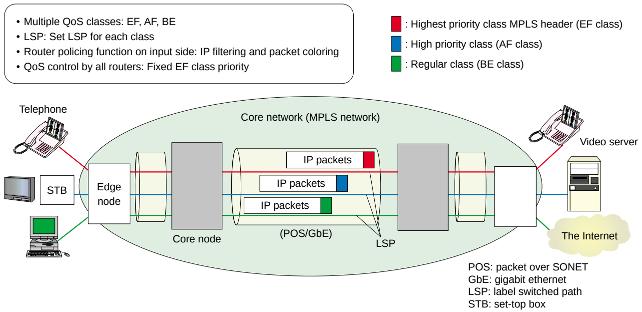

Fig. 3. Core network architecture.

large volumes of traffic that is both flexible and cost-effective is multilayer pass-through technology, illustrated in Fig. 4. Essentially this involves marrying the advantages of WDM technology and OXC and other optical switching technologies with IP and other types of packet handling. Traffic is delivered by edge nodes that map different service flows identified by MAC (media access control) address, VLAN tag, ATM header, IP address, QoS identifier, and so on to an optical path at the starting point and core nodes that handle the high-speed delivery over the optical paths. The virtue of this approach is that the traffic is delivered very quickly and cost-effectively over high-speed paths by the large-capacity core nodes, while

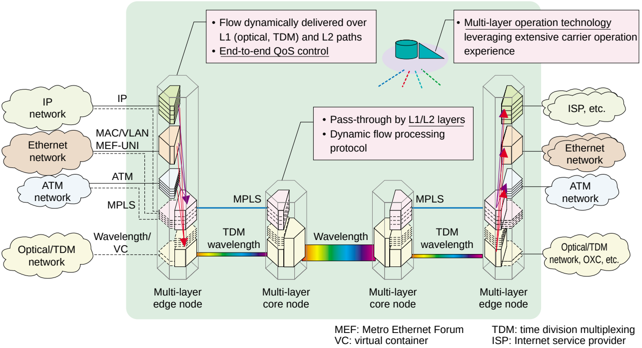

Fig. 4. Multi-layer pass-through technology.

quality control is achieved by the edge nodes by determining the character of the traffic flows and connecting those flows to the optimum optical paths.

7. Future prospects

This article presented an overview of the transport system architecture that provides the core network functions required for implementing RENA services. Special emphasis will be focused on the interconnection between the service control platform and the home gateway at the interface with user networks because this enables the security, QoS, reliability, and other features of RENA. The development and deployment of services on RENA based on this interconnection will not only enable the provisioning of reliable end-to-end communications and significantly enhance the usability to end users, but will also lead to the creation of many new business opportunities and markets.

References

[1] N. Wada, "Vision for a New Optical Generation—Broadband Leading to the World of Resonant Communication," NTT Technical Review, Vol. 1, No. 1, pp. 6-17, 2003.

[2] Y. Inoue, "Achieving "Resonance of Knowledge"—NTT's R&D strategy to provide the basis for its envisaged resonant communications," ibid., Vol. 1, No. 1, pp. 18-25, 2003.

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