Anycast-Based Mobility

István Dudás
Budapest University of Technology and Economics, Hungary

László Bokor
Budapest University of Technology and Economics, Hungary

Sándor Imre
Budapest University of Technology and Economics, Hungary

INTRODUCTION

We have entered the new millennium with two great inventions, the Internet and mobile telecommunication, and a remarkable trend of network evolution toward convergence of these two achievements. It is an evident step to combine the advantages of the Internet and the mobile communication methods together in addition to converge the voice and data into a common packet-based and heterogeneous network infrastructure. To provide interworking, the future systems have to be based on a universal and widespread network protocol, such as Internet protocol (IP) which is capable of connecting the various wired and wireless networks (Macker, Park, & Corson, 2001).

However, the current version of IP has problems in mobile wireless networks; the address range is limited, IPv4 is not suitable to efficiently manage mobility, support real-time services, security, and other enhanced features. The next version, IPv6 fixes the problems and also adds many improvements to IPv4, such as extended address space, routing, quality of service, security (IPSec), network autoconfiguration and integrated mobility support (Mobile IPv6).

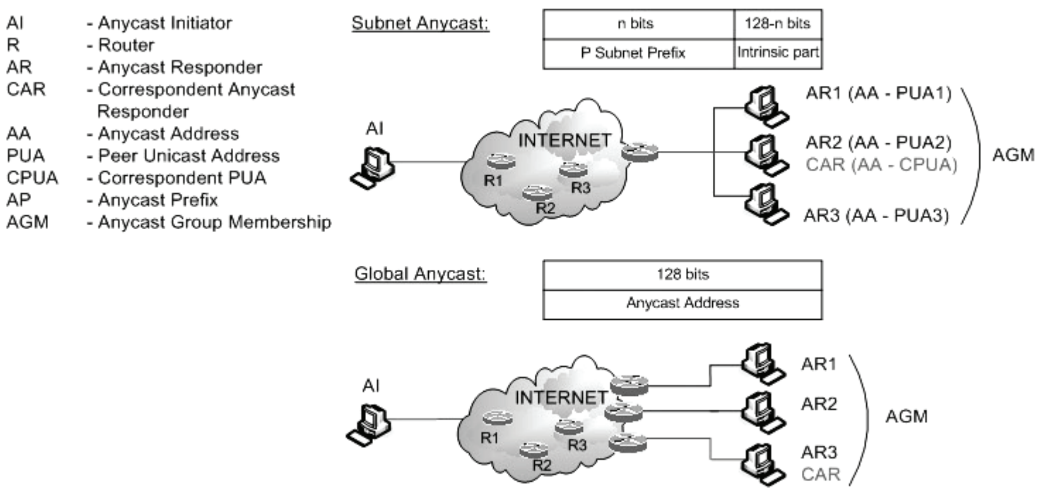
Today's IP communication is mainly based on unicast (one-to-one) delivery mode. However it is not the only method in use: other delivery possibilities, such as broadcast (one-to-all), multicast (one-to-many) and anycast (one-to-one-of-many) are available. Partridge, Mendez, and Milliken (1993) proposed the host anycasting service for the first time in RFC 1546. The basic idea behind the anycast networking paradigm is to separate the service identifier from the physical host, and enable the service to act as a logical entity of the network. This idea of anycasting can be achieved in different layers (e.g., network and application layers) and they have both strengths and weaknesses as well. We focus on network-layer anycasting in this article, where a node sends a packet to an anycast address and the network will deliver the packet to at least one, and preferably only one of the competent hosts. This approach makes anycasting a kind of group communication in that a group of hosts are specified for a service represented by an anycast address and underlying routing algorithms are supposed to find out the appropriate destination for an anycast destined packet.

OVERVIEW OF IPV6 ANYCASTING

RFC 1546 introduced an experimental anycast address for IPv4, but in this case the anycast addresses were distinguishable from unicast addresses. IPv6 adopted the paradigm of anycasting as one of the basic and explicitly included services of IP and introduced the new anycast address besides the unicast and multicast addresses (Deering & Hinden, 1998). IPv6 anycast addresses were designed to allow reaching a single interface out of a group of interfaces. The destination node receiving the sent packets is the "nearest" node. The distance is dependent on the metric of the underlying routing protocol. In case of IPv6, an anycast address is defined as a unicast address assigned to more than one interface, so anycast addresses can not be distinguished from unicast addresses: they both share the same address space. Therefore the beginning part of any IPv6 anycast address is the network prefix. The longest *P* prefix identifies the topological region in which all interfaces are belonging to that anycast address reside. In the region identified by *P*, each member of the anycast membership must be handled as a separate entry of the routing system. Based on the length of *P*, IPv6 anycast can be categorized into two types: subnet anycast and global anycast. Hashimoto, Ata, Kitamura, and Murata (2005) summarized all that issues and defined the main terminology of IPv6 anycasting (Figure 1).

Hinden and Deering (2003) declared some restrictions concerning the further usage of the anycast addressing paradigm. The main purpose for setting these limitations was to keep the usage of anycast addresses under control until enough experience has been gathered in order to fit this new scheme to the existing structure of the Internet. These restrictions are now being eased that research could find appropriate solution for them (Abley, 2005). The biggest concern that had to be dealt with was routing since anycast packets (packets with an anycast address in the destination

Figure 1. IPv6 anycast terminology basics



field) might be forwarded to domains with different prefixes, as anycast receivers might be distributed all over the Internet. As a result a scalable and stable routing solution for anycasting is necessary.

Routing Protocols for IPv6 Anycasting

The current IPv6 standards do not define the anycast routing protocol, although the routing is one of the most important elements of network-layer anycasting. There is a quite small amount of literature about practical IPv6 anycasting. Park and Macker (1999) proposed and evaluated anycast extensions of link-state routing algorithm and distance-vector routing algorithm. Xuan, Jia,, Zhao, and Zhu (2000) proposed and compared several routing algorithms for anycast. Eunsoo Shim (2004) proposed an application load sensitive anycast routing method (ALSAR) and analyzed the existing routing algorithms in his PhD thesis. Doi, Ata, Kitamura, and Murata (2004) summarized the problems and possible solutions regarding the current specifications for IPv6 anycasting and proposed an anycast routing architecture based on seed nodes, gradual deployment and the similarities to multicasting. Based on their work, Matsunaga, Ata, Kitamura,and Murata (2005) designed and implemented three IPv6 anycast routing protocols (AOSPF—anycast open shortest path first, ARIP—anycast routing information protocol and PIA-SM—protocol independent anycast - sparse mode) based on existing multicast protocols.

The recent studies are focusing on subnet anycast routing protocols since they offer various possibilities for research while global anycast routing still faces scalability problems to be solved. The recently introduced anycast routing protocols all share a common ground as they are all based on multicast routing protocols because of the similarities of the two addressing schemes.

Unfortunately it does not fit the scope of this document to introduce each anycast routing protocol one-by-one although it is important to present the main idea that lies beneath all these protocols. The principal task to be performed is to discover all the anycast capable routers and nodes in the network: this can happen by flooding (as in case of AOSPF) or discovery methods (e.g., PIA-SM). The next, and maybe the most important step, is to maintain an up-to-date anycast routing table so all possible receivers could be reached in case of need. The easiest way to keep the routing entries up-to-date is to maintain a so-called Anycast Group Membership (Figure 1) where the anycast hosts can sign in or out when joining or leaving a certain anycast group designated by its anycast address.

APPLICATIONS OF ANYCASTING

Since the introduction of IPv6 anycast only a few applications have emerged using these addresses. It is mainly because the flexibility of the anycasting paradigm has not yet been widespread in the public. An excellent survey of the IPv6 anycast characteristics and applications was made by Weber and Cheng, 2004; Doi, Ata, Kitamura, and Murata, 2004; Matsunaga, Ata, Kitamura, and Murata (2005), where the authors describe many advantages and possible applications of anycasting. These applications can be classified into the following main types.

Main Application Schemas

The most popularly known application of anycast technology is helping the communicating nodes in selection of service providing servers. In the *server selection* approach the client host can choose one of many functionally identical servers.