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A Bio-Inspired Proposal for Internet Address System Modification

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ABSTRACT

This paper presents a provisional design proposal for the modification of the numbering and address representation of Internet Protocol 4 (IPv4), the Internet address system nearing exhaustion, based on biology. Biologically-inspired designs have been applied in diverse technological fields with varying degrees of successes. The paper proposes the expansion of IPv4 addresses by the concatenation of twelve 8 bit suffixes to each IPv4 address using numbers derived from DNA sequences. The author outlines a design proposal for the modification of the addressing system of the network layer in the TCP/IP hierarchy. This scheme, if deemed possible, could see the creation of at least 6.4×10^{26} unique addresses and prolong the usefulness of IPv4, beyond the projected operational time frame of ten years.

Keywords: Internet protocol; modification of IPv4; design; biomimetics.

1. INTRODUCTION

In the past decade, the field of computer science has been extended to incorporate biomolecules (Benenson and Shapiro, 2004). Biomolecules, notably DNA, have been programmed to attempt practical problems, such as breaking the Data Encryption Standard of the U.S. government (Boneh et al., 1996; Adleman et al., 1999). As a consequence, there has emerged the field of bio-computing, which has witnessed the use of biomolecules in the execution of complex problems in computer science (Quyang et al., 1997; Pirrung et al., 2000) and the laboratory construction of autonomous machines (Venkataraman et al., 1997;

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Lund et al., 2010). The basic design of the DNA molecule composed of four nucleotide bases in sixty-four triplet codons (Nelson and Cox, 2000) has been exploited to program surprisingly complex automata.

Biology has often inspired the design of useful devices such as the silicon cochlea (Mandal et al., 2009); flight mechanisms based on insect flight (Ellington, 1999), Extrusion technology based on the spinneret of the spider (Knight and Vollrath, 1999) and Velcro (Velcro, 1955). This concept of using ideas from biology to further technology is called biomimetics (Vincent and Mann, 2002). Here, the author discusses the possibility of employing numbering derived from DNA segments in the modification of the numbering of addresses and as a consequence expansion of address space in Internet Protocol version 4 (IP v 4).

An Internet Protocol Address is an identifying number assigned to hosts that want to participate in a Transmission Control/Internet Protocol (TCP/IP) standards internet (Ranalli et al*.,* 2003). An IP address is an abstraction of the physical hardware addresses just as the internet is an abstraction of physical networks (Ranalli et al*.,* 2003). Currently, Internet Protocol version 4 (IPv4) is the most widely deployed Internet Protocol and is described in the Internet Engineering Task Force (IETF) publication RFC 791 (Postel, 1981). IPv4 employs 32 bit addresses, limiting the available internet address space to just over 4 billion unique addresses (2^{32}). IP v 4 is nearing exhaustion, though it is still expected to be in use for at least the next decade (BBC Technology Report, 2011a). This has induced the development of Internet Protocol version 6 (IPv6), which makes use of 128 bit addresses, making for about 3.4×10^{38} unique addresses (2^{128}). IPv6 is described in IETF publication RFC 2460 (Deering and Hinden, 1998). This paper proposes the modification of IPv4 address spaces by concatenating a 96 bit suffix to each IPv4 address. The allocation of Internet Addresses is done by Internet Assigned and Numbers Authority (IANA) through the 5 Regional Internet Registries (RIR's) of North America (ARIN), Latin America (LACNIC), Asia Pacific (APNIC), Africa (AfriNIC) and Europe (RIPE NCC) through to the Network providers and Internet service providers (ISP's).

The proposed suffix consists of twelve octets (8 bits) modeled after the number system inherent in DNA segments (Table 1). The numbering system in Watson-Crick DNA segments* have been conceived as hypothetical steganographic media (Okunoye, 2011). Here, the combinations of DNA nucleotides in DNA segments which can be encoded with 8 bits are used as proposed suffixes to addresses in IPv4.

2. THE TCP/IP HIERARCHY

The protocols (Table 2) that govern the operation of the Internet are set up as a multi-layered hierarchy, called the Transmission control protocol/Internet protocol (TCP/IP) hierarchy, after the names of two of its most important protocols (Schneider and Gersting, 2007).

The critical function of the Network layer, also called the Internet Protocol (IP), is to create a universal addressing scheme for all network nodes or hosts, and the delivery of messages between any two nodes in the network. The network layer of the Internet (IP) is an inherently unreliable communication channel, using a *good faith* transmission model, which means it tries very hard to deliver a message from source to destination, but it does not guarantee delivery (Schneider and Gersting, 2007). Although IP always attempts to deliver a packet, a packet may be lost, corrupted, delivered out of sequence, duplicated or delayed. Acknowledging the receipt of packets and recovering lost packets is the responsibility of a higher-layer protocol such as TCP. Other functions of the Network layer include network management, broadcasting, and locating mobile nodes that move around the network.

Table 1. Number Permutations Used as Address Suffixes

Number Combinations	Permutations	Number of Permutations
0,0,1,9	19, 91, 109, 190	4
0,0,2,8	28, 82, 208	3
0,0,3,7	37, 73	2
0,0,4,6	46, 64	2
0,0,5,5	55	1
0,1,1,8	118, 181	2
0,1,2,7	127, 172, 217	3
0,1,3,6	136,163	2
0,1,4,5	145, 154	2
0,2,2,6	226	1
0,2,3,5	235, 253	2
0,2,4,4	244	1
0,0,0,10	10, 100	2
Total		27

*Table 1 shows twenty-seven octets (8 bits each), the basis for the proposed suffixes to each IP v 4 address. By creating a twelve length suffix (96 bits), we obtain a possible 27^{12} suffixes, which concatenated to each IP v 4 address creates a possible 6.4×10^{26} unique addresses. It could be observed that these DNA derived octets are already a part of the regular IPv4 numbering, only that the DNA derived octets all have the sum of ten, which distinguishes them from the regular IPv4 numbers. The choice of 12 octets (96 bits) was suggested by the size of address space in IPv6 which is 128 bits. Adding 96 bits to the 32 bits of IPv4 will give us 128 bits of address space, the same as IPv6. It should be noted that double stranded DNA is formed by Watson-Crick base pairing and exhibits helical turns of about 10.5 bases. As in the work where DNA was conceived as a hypothetical steganographic media, only one chain of the helix is under consideration and the number of nucleotides is only rounded off to 10 for simplicity and convenience of analysis.

3. IPV4 ADDRESS REPRESENTATION

IPv4 addresses are most commonly expressed in dot decimal representation, denoting a 32 bit integer value in a fixed length of four octets (Postel, 1981). For example, the following is a valid IPv4 address: 112.223.189.123. The restriction in the size of IPv4 addresses to a 32 bit integer value limits the possible unique address space to just over four billion addresses. Although techniques such as Network address translation (Srisuresh and Holdrege, 1999) have been used to prevent exhaustion of IPv4 addresses, it might prove useful to explore the catenation of a suffix of a fixed length at the end of each IPv4 address.

Table 2. The five-layer TCP/IP Internet Protocol Hierarchy

Layer	Name	Examples
5	Application	HTTP, SMTP, FTP, DNS, POP3
4	Transport	TCP, UDP
3	Network	IP
2b	Logical Link Control	PPP, Ethernet (Data link layer)
2a	Medium Access Control	Ethernet (Data link layer)
1	Physical	Modem, DSL, Cable Modem

4. IPV6 ADDRESS REPRESENTATION

IPv6, described in IETF publication RFC 2460 (Deering and Hinden, 1998), was designed to replace IPv4 as IPv4 address spaces near exhaustion. One of the major features of IPv6 is its larger address space, compared to IPv4. By using a longer address representation of 128 bits, IPv6 provides 2^{128}(about 3.4×10^{38} unique addresses). IPv6 addresses are denoted by eight groups of hexadecimal quartets separated by colons in between them. The following is an example of a valid IPv6 address: 2001:cdba:0000:0000:0000:0000:3257:9652

Any four digit group of zeroes within an IPv6 address may be further reduced to a single zero or omitted. Therefore the following IPv6 addresses are similar and equally valid: 2001:cdba:0:0:0:3257:9652 and 2001:cdba:3257:9652. Leading internet firms have set 6th June, 2012 as the world IPv6 launch day (BBC Technology Report, 2012).

5. NUMBERING FROM DNA FOR IPV4 REPRESENTATION

To employ numbering inherent in DNA to modify IPv4 address representations, the proposal is to concatenate twelve octets (96 bits) to an IPv4 address. For example, using the IPv4 address 112.223.189.123, we add the octets 235.109.118.235.28.190.91.82.73.37.253.127 to give the expanded address representation 112.223.189.123**:** 235.109.118.235.28.190.91.82.73.37.253.127.

6. DISCUSSION

It is envisaged that both IPv4 and IPv6 will co-exist for many years (Carpenter et al.*,* 2000). However, as at 2008, IPv6 penetration was still less than 1% in any country (Gunderson, 2008). And although IPv4 addresses are nearing exhaustion, they are still expected to be in use for at least the next decade (BBC Technology Report, 2011a). By modifying IPv4 addresses using this simple design mechanism, it might be possible to prolong its usefulness beyond this timeline as it is the addressing system already deployed in the majority of computers and electronic devices.

Another cogent reason for the modification of IPv4 address space is the resulting expansion of possible address spaces which will cater for the proliferation of internet connected devices, called the “Internet of things” (BBC Technology Report, 2011a).

The internet is evolving. The Internet Corporation for Assigned Names and Numbers recently approved the increase in the number of internet domain name endings or generic top-level domains (ICANN, 2011). This allows the creation of new website domain suffixes, distinct from the 22 generic top-level domains such as .com and the country-level domain names such as .uk (BBC Technology Report, 2011b).

This proposal is provisional and relates only to the Internet Protocol address representations. The internet is a huge and very visible infrastructure used by many users. The network layer (IP) in itself is a complex piece of software, extending beyond numbering. The final shape of any proposed modification will ultimately involve the input of multiple experts and industry collaboration in order to be feasible.

7. CONCLUSION

When we innovate we commonly fail to take advantage of the solutions and practices of other sciences and technologies or to recognize the similarities between our technical problems and solutions to similar problems in otherwise alien fields (Vincent and Mann, 2002). This design proposal for IPv4 address modification takes an idea from biology for application in computer science. This work touches an aspect of Internet Protocol 4, namely the numbering and address representation. More technical specification and work is needed, if this design is deemed feasible, to bring it into operability.

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COMPETING INTERESTS

The author has declared that no competing interests exist.

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