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A Review on Implementation Issues in IPv6 Network Technology

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***Abstract*— IPv4 addresses are already depleted in Internet *Assigned Numbers Authority* (IANA) and have exhausted in R*egional Internet Registries (*RIRs) while more clients are continuously adding into the Internet. IPv6, as the only available next generation Internet protocol, is still not commercially successful accepted because a scheme that could solve the migration of IPv4 resources to IPv6 network, as well as mutual communication between the two incompatible protocols, has not been fully developed and deployed. Translation solution provides a proper approach to address this problem. In this review paper, we reviewed research papers presented by the researchers between 2007 and 2015 related to IPv4 & IPv6 resource migration and protocol transition schemes and observed issues related network security, addressing and error detection in the implementation of IPv6.**

Keywords: IPv6 Network Architecture, Security, Addressing, Error Detection, Wireless Networks.

INTRODUCTION

Internet Protocol version 6 (IPv6) is a new generation protocol of the basic internet protocol. Internet Protocol (IP) is a common language of the Internet, every device connected to the Internet must support it. The current version of IPv4 (IP version 4) has several shortcomings which are unavoidable and complicate such exhausted address space, security issues, non availability of auto-configuration and in some cases present a barrier to, the further development of the Internet. The coming IPv6 revolution should remove these barriers and provide a feature-rich environment for the future of global networking. Internet Engineers Task Force released the first RFC specifying the IPv6 were released at the end of 1995 and continuously trying to improve it. Since 1995 IPv6 has not been implemented in completely in real world due some issues like availability of alternative solutions in IPv4, non availability of compatible software, financial investment required in term of compatible equipments, software and security systems. Therefore issues involve in ipv6 implementation has to be analyzed and found the solutions for some of the issues. Further in this section IPv4 and IPv6 described briefly.

IPv4 is the first version of Internet Protocol to be widely used, and accounts for most of today's Internet traffic. There are just over 4 billion IPv4 addresses. While that is a lot of IP addresses, it is not enough to last forever. IPv6 is the sixth revision to the Internet Protocol and the successor to IPv4. It functions similarly to IPv4 in that it provides the unique, numerical IP addresses necessary for Internet-enabled devices to communicate. However, it does sport one major difference: it utilizes 128-bit addresses. We will explain why this is important in a moment.

The major difference between IPv4 and IPv6 is the number of IP addresses. There are 4,294,967,296 IPv4 addresses. In contrast, there are 340,282,366,920,938,463,463,374, 607,431,768,211,456 IPv6 addresses. The technical functioning of the Internet remains the same with both versions and it is likely that both versions will continue to operate simultaneously on networks well into the future. To date, most networks that use IPv6 support both IPv4 and IPv6 addresses in their networks.

TABLE 1: MAJOR DIFFERENCE BETWEEN IPv4 AND IPv6

Key	IPv4	IPv6
Deployment started in	1981	1999
Address Size	32-bit number	128-bit number
Address Format	Dotted Decimal Notation: 192.149.252.76	Hexadecimal Notation: 3FFE:F200:0234:AB00: 0123:4567:8901:ABCD
Prefix Notation	192.149.0.0/24	3FFE:F200:0234::/48
Number of Addresses	2^{32} = ~4,294,967,296	2^{128} = ~340,282,366, 920,938,463,463,374, 607,431,768,211,456

REVIEW PROCESS ADOPTED

The research works published and presented in international reputed journals such as IEEE, Springer, Elsevier etc were taken corresponding to IPv4. The process of the finding review information is mentioned below. The research papers have been studied twice to thrice and prepared the summery and findings paper by paper. The papers have been categorized in four issue categories such as Network Security, Addressing and Error Detection arranged them as per their category. The Key findings have been prepared according to the category and a reference list of all papers has been prepared taking information from papers like Id, Author, Year of Publication, Title, Name of Journal, Name of Publisher, Place of Conference (if any), Volume, Issue, Page Number, Area/ Sub area, and Keys. A sheet was prepared and entered all the information in the sequence as mentioned earlier. The following questionnaire and stages have been used to understand and study the research paper properly: What research area/sub topic does the paper fall under? What problem does the paper attempt to solve? What is the motivation for the problem? What is related work and why is it not sufficient, what are gaps? What key contribution does the paper claim- idea, technique, proof, result etc? Broadly how does the paper solve the problem? How do the authors defend the solution? What is the precise research question addressed? Why is it believed that solution works, better than previous? What are assumptions & scope? What are details of proposed solution - argument, proof, implementation, experiment? What evidence is provided? What is the take away message from the paper? Answers of these questions have been found reading research paper following five stages as mentioned below:

In stage one, we have to get a "feel" for the paper by reading the title, seeing how long the paper is (2 to 40+ pages), where is the paper published, looking at the figures, reading section / sub-section headings. We have to locate the parts such as Title, Abstract, Introduction, Background / Motivation, Contribution of paper, Related work, Problem definition (research questions), Scope/Assumptions/ Limitations, Solution approach, Details of solution - experiment/ system / model, Findings, Evaluation in the uploaded paper and high light on paper.

In stage two, we have to get a big picture about the paper by reading such as title, abstract, introduction, conclusion, by going through the section and sub-section headings and by looking at figures. We have to answer to such questions as what research area / sub-topic does the paper fall under? What problem does the paper attempt to solve? What is the motivation for this problem? Why this paper is needed – i.e. what is related work and why is it not sufficient? What key contribution does the paper claim? Broadly, how does the paper solve the problem? How do the authors defend the solution? What category of paper is this? Making notes while reading paper in margins, using highlighter, in separate notebook / file, references.

In stage three, we have to get details mentioned in the table 1:

Table 1: Stage three details

What we are looking for	Where to find it
What problem does the paper attempt to solve?	Introduction, Problem definition
What is related work? What are gaps?	Introduction, Literature Survey or Related Work
What contribution does the paper claim – idea, technique, proof, surprising result etc?	Introduction, Conclusion
How does the paper solve the problem?	Solution, Experiment, figures
How do the authors defend the solution?	Methodology, Experiment, Results
What is the precise research question addressed?	Introduction, Problem definition
Why is it believed that solution works, better than previous?	Solution approach, figures
What are assumptions, scope?	Problem definition, solution approach
What are details of proposed solution – argument, proof, implementation, experiment?	Solution, System details, Experiment, Methodology, figures
What evidence is provided?	Figures, Results
What is the take-away message from the paper?	Overall

In stage four, we have to evaluate details like: Is the research problem significant? Is the problem novel? Is the solution approach novel? Are the contributions significant? Is relevant related work surveyed "sufficiently" enough? Have alternate approaches of solution been explored? Are assumptions valid? Has paper violated assumptions? Are the claims valid? Are the different parts of the paper consistent? Are the figures, graphs, diagrams precise? Does the paper flow logically? What is the paper trying to convince you of? Does it succeed?

In stage five, we have to synthesize & ask creative questions such as what are some alternative approaches to address the research problem. Could there be a different way to substantiate the claim? Are their counter-examples or arguments against the paper's claims? Are all assumptions identified and validated? How can the research results be improved? How can the results be generalized? What are the new ideas and open problems suggested by this work?

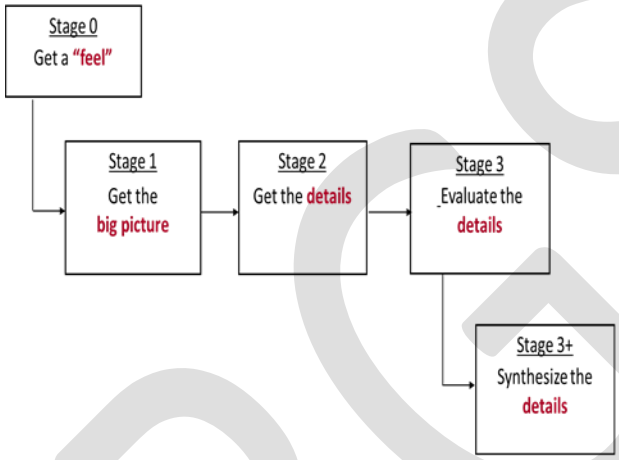

Figure 1: Five stages for reading a research paper

LITERATURE REVIEW

IPv6 Network Technology is becoming popular day by day and the people are accepting the improvements provided in it in respect to the current IPv4 Network Technology. The literature review was carried out taking research papers various reputed journals such as IEEE, Springer & Elsevier in the field of IPv6 network technology implementation and after reviewing research papers we found that there major issues were addressed by the researchers in their research papers are such as Security Issues, Addressing Issues, Error Detection Issues and Optimization Issues. The reviewed papers were categorized as per the issues addressed by them and prepared the summery of paper and issue wise common findings and combined findings of the all issues. The issues-wise number of research papers reviewed are mentioned in the Table 2 as below.

Table 2: Issue-wise number of paper reviewed

Issue	No of Papers
Security	72
Addressing	27
Error Detection	7
Optimization	22

IPv6 Network Security issues were addressed in 72 papers and it has been observed that security meseasurs taken in IPv6 for LAN and WAN cannot be applied in Wireless Sensor Networks(WSN) as it was due to the less processing ability and limited energy resource and it hindered the IPv6 implementaion in WSN. In paper [54] researchers have porposed an compressed Authentication Header (AH) and Encapsulating Security Payload (ESP) to use the IPSec in IPv6 over Low power Wireless Personal Area Networks (6LoWPAN) and it reduced size of IPSec Header to reduce the processing cost and increase the energy efficiency. Interfece ID aloing with Simple Secure Address System (SSAS) was proposed in [89] to secure host address from various security attacks by generating

random IPv6 addresses. One more approach Secure Address Validation Improvement (SAVI) propsoed by the researchers [128] to provided validation check of the IP address binding it on FCFS basis with network switch port and MAC address of the host creating a binding table at switch level. Later Internet Engineers Task Force (IEFT)[9] had accepted the SAVI as a standard for protection from spoofing attacks. The researches [95] have proposed i-SeRP system for assesment of vulenrabilities of IPv6 and other researchers [73] desinged and implemented 6Foren which was an online network foreincics prototype system in IPv6 enfiromement for HTTP, FTP, SMTP & POP protocols.

In IPv6 implementation, addressing issues were also faced and the the researchers provided various approaches and solutions to deal with them. It could be found during review many reseachers were dealing with this issue. One paper [36] proposed a Micro Sensor Routing Protocol for the wireless network to provide better performance than an Demand Distance Vector (AODV) algorithm. The reseach paper [49] proposed an IPv6 in IPv4-UDP tunneling protocol to provide the IPv6 in IPv4 and it improved the packet's poor latecy in relay time in respect to Miredo-relay from 9.76us to 8.21us. The Escort protocol analysed on the basis of packet processing latency and it was around 6us ~ 10us along with more security, sported mobility and multi-homing with capability of traversing symmetric NATs. In [58] had poposed an IPv6 address auto-configuration in LoWPAN along with AH & ESP and Policy Based Security for 6LoWPAN.

In the error detection paper [101] propsoed improved CRC based Packet Recovery Mechanism for Wireless Network to reduced computation and resource consumption for CRC based Packet Recoveries. The paper proposed [86] CRC checking at Network Layer to reduce link layer processing overheads and increased the performance of link layer.

In the Network Optimization paper [103] proposed Memory Management system to overcome the memory buffer overflow issue in implementaion of IPv6 in LoWPAN. The paper [97] proposed IPv6 based Database Retrieval System for Wireless Sensor Networks using BLIP to establish connectivity.

The major approaches /Techniques proposed by the researchers are mentioned below table 3.

Table 3: Issue-wise Major Solution Approaches

Approach/ Technique Used	Problem solved
• **Security Issues**	
Compressed AH & ESP for 6LoWPAN	Successful secure integration of IPv6 WSN with the internet.
Policy Based Security	Policy Based Security Management (PBSM) new theoritical approach to allow the secure deployment of the host based security (HBS) system
Simple Secure Addressing Scheme (SSAS)	Sucessfully provided privacy & security by randomizing the IID, adding SSAS signature, using RPKI and binding between the public key and IP address
Object Risk Based Access Control (OrBAC)	Conceptual Security mechanism for new distributed firewall techniques.
Secure address Validation Improvements (SAVI)	System protected from address resolution attacks by checking NS & NA messages coming from validating ports.
i-SeRP risk assessment system	Developed tool useful for assessment of the IPv6 network security risks
Online Forensic tool (6Foren)	6Foren system sucessfully recorded attack event replays in Attack Event Database
• **Addressing Issue**	
Micro Sensor Routing Protocol	carried out performance comparisons on Packet Delivery Ratio, Average End to end Delay and Routing Overhead and MSRP has better performance compared to AODV.
Escort Tunneling Protocol	Escort protocol analysed on the basis of packet processing latency and it was around 6us ~ 10us along with more security, sported mobility and multi-homing with capability of traversing symmetric

	NATs .
Auto-configuration Implementation in LoWPAN	Theoritically reduced the header size and decreased the communication and save nodes energy to extend the average life time of the entire network.
• **Error Detection Issue**	
CRC based Packet Recovery Mechanism for Wireless Network	System reduced computation and resource consumption for CRC based Packet Recovery
CRC checking at Network Layer	reduced link layer processing overheads and increased the performance of link layer
• **Network Optimization issues**	
Memory Management system in 6LoWPAN	Buffer Overflow memory problem was successfully resolved in Wireless Sensor Networks
IPv6 based Database Retrieval System for Wireless Sensor Networks	It provided the concept for the research to implement database retrieval system in the Wireless Sensor Networks.

In this section we mentioned the technologies and approached discussed in various papers and the next section will discussed about the key findings of this review paper.

IV KEY FINDINGS OF SURVEY

In this section we mentioned the various key findings in the field of Security, address, Error detection and Wireless Sensor issues addressed by varous papers for implementaion of IPv6.

Out come of survey in Network Security:

- Researchers implemented AH & ESP technologies for 6LoWPAN and Policy Based Security.
- Moving Target IPv6 Defense custom security application, Email spam filtering techniques, Simple Secure Addressing Scheme, Trust Relationship with DNS Server, i-SeRP risk assessment system, data structure based on SNMP and Netflow, Online Forensic tool, Source Address Validation Improvements(SAVI), Object Risk Based Access Control (OrBAC) techniques were proposed.
- It could be found that some techniques required more computational cost for sharing security information and sometimes required manual intervention.
- Security provisions and techniques discussed were OPNET System-in-the-Loop, IP Packet Header, Asymmetric Cryptography, Secure Neighbor Discovery, DNS RDATA Field, ACK-Reset and packet Fragmentation, SNMP data, Netflow record, IPSec & SAVI.
- Antispoofing approaches were proposed by the researchers at Inter-AS such as
  - IEF Ingress/Egress Filtering
  - DPF Distributed Packet Filtering
  - uRPF Unicast Reverse Path Forwarding
  - IDPF Inter-Domain Packet Filter
  - SPM Spoofing Prevention Method
  - MEF Mutual Egress Filtering
  - Passport Packet Passport
  - SAVE Source Address Validation Enforcement
- Most of the approaches for against IP spoofing, DNS Dynamic Update Spoofing, SYN Flood were tested using test-beds or networks simulators like Graphics Network Simulator – 3.
- SAVA protocol/architecture was first proposed in 2007 for Inter-AS, Intra-AS and First-hop only but did not considered dynamic behavior of network hardware & mobility of devices. SAVD device was first implemented in 2008 using SMP & ARBIF and tested for spoofing attacks but found performance degradation in terms of packet drops.
- Later in 2009 SAVA was modified as SAVI with fine grained Intra-domain filtering mechanism using truth chains between source IP address & associated Leyer-2 & further in 2011 few experimentation on SAVI were carried out but without considering dynamic behavior of the network handover and mobility.
- In 2011 SAVI was modified as VAVE (Virtual-source Address Validation Edge) to filter legacy traffic but with increased overhead. SAVA was implemented with cryptographic technique (hash function) for improving security in simulation environment. Various variants of SAVI was proposed in subsequent researches such as In 2012 FCFS-SAVI was applied to MAC layer but with increase in processing load on CPU, In 2012 SAVE & SIP based SAV was proposed integrating with password with theoretical validation.

- In 2014 SAVI was tested for CPU utilization in simulation experiments.
- In 2015 as comparative study of various security mechanisms such as IEF, DFP, uRPF, IDPF, SAVE, SPM and Passport has been carried out with respect to deployment benefits, cost and risk and found that SAVE posses medium level of characteristics for all the those, however SPM and Passport could provide better scenario when tested with different filtering mechanisms in Inter-AS collaboration.
- Other antispoofing mechanisms & security methods proposed were Passport (2009), Link-State based Antispoofing (2014) but former has added time & space overheads and the later had limitation of compatibility with other link-state protocols other than OSPF.
- A study of authentication and privacy protection in 5G HetNets using SDN has been carried out in 2015 but for limited number of 5G cells in MatLab environment proposed two algorithms; one for user SCI based authentication handover and other for partial data offloading in SDN controller data paths.

Out come of survey in IPv6 Addresssing:

- Authors implemented Dual Stack Networks and IPv6 Address Auto-configuration in 6LoWPAN.
- Researchers developed techniques such as Micro Sensor Routing, Escort Tunneling system, Fragment & Header Size Optimization for LAN, Mobile Routing and Proxy Mobile IPv6 for Network Mobility, IPSec gateway failure prevention & Network Performance Testing tools.
- Most of techniques were implemented and tested using network simulators for evaluation of performance of the proposed solutions and few of them used the real test environment.
- Research works discussed various issues of IPv6 Addressing like auto-configuration, security during dual stack, security lapses and algorithms like routing, NAT, CGA, SEND, MAC & Multicasting.

Out come of survey in Error Detection :

- Algorithms were proposed to reduce processing time in high speed data transmission, CRC based Packet Recovery Mechanism for Wireless Network, CRC checking at Network Layer to reduce link layer processing overheads and comparative study was carried out for various error detection & correction techniques.
- Gigabit Ethernet Network was used for testing of the proposed algorithms and some of them used the Simulators for testing of the algorithms.
- CRC checking was carried out at Network Layer reduced link layer processing overheads and increased the performance of link layer.
- CRC checking algorithms can be optimized for the various types of networks and need the testing in the real time network environment.

Out come of survey in Network Optimization:

- IP Header Compression Techniques were proposed by researchers such as Stateless IP Header Compression (2005), Layered IP Header Compression for IP-enabled Sensor Networks (2006), Robust Header Compression in Network Mobility Applications (2008), Tunneling Header Compression Protocol(TuCP) in Wireless Network (2010), End-to-End Header Compression over SDNs(2012), Header Compression in Cellular IP Networks(2012), Header Compression Scheme in 6LoWPAN(2013) , Mobile Adhoc Networks (MANET) IP Header Compression (MIPHC) (2013) to reduce size of header and enhance the speed of a specific type of network traffic.
- The most of the researches proposed some improvements & modifications in the earlier proposed Header Compression technique.
- In 2008 a Memory Management System for IPv6 Wireless Sensor Networks was proposed to resolve the buffer overflow problems during 6LoWPAN implementation.
- In 2012 a comparative study on routing schemes of IP based WSN was carried out to check the performance of two schemes and proposed an improved route-over scheme to apply this Sensor-Grid Infrastructure in health-care application.
- In 2012 an implement IPv6 based Data Retrieval System for WNS research was proposed and successfully implemented in the test environment.
- In 2012 & 2013 surveys on ROHC header compression schemes were carried out to illustrate the states and modes, process of the compressor and de-compressor
- In 2013 a better Network Latency with End-to-End Header Compression in Software Defined Networking Architecture was proposed to reduce the packet size and time delay.

In this section we mentioned the various technologies proposed by the research papers during our review and next section will discussed the objective the this litrature review paper.

V OBEJCTIVES OF LITRATURE REVIEW

We proposed a review of the techniques and approaches proposed the various researchers for addressing IPv6 implementation issues related Security, addressing, Error detection and Wireless Network. As per our review we found that most of the researchers have worked in the field of the Security issue and Addressing issues still there is scope for the research in this area and test the solution by implementing in real world. The error detection techniques are very much required which should provide the high performance in the Ethernet network. In the current world wireless network is becoming very popular and it is involved in the every one's life. Various issues in wireless network are to be addressed to implement IPv6 application in with high performance and low power requirements.

CONCLUSION

The literature review has been carried out in the field of IPv6 Network Technology Implementation downloading papers published between 2007 and 2015 in IEEE journals & conferences to get status of the technology implementation, issues faced during implementation and which are still required to be resolved by doing further research. After review of 128 research papers we found that there were four basic issues faced in the technology such as Security issues, Addressing issues, Error detection issues and Wireless Sensor Network issues. The researchers have provided various solutions for the issues faced in implementation of IPv6 which have been discussed above in section III of this paper. It has been observed after literature review that there are many gaps in the research papers and needs more work to be done further. The identified research fields may be in the area of Security Solutions, Addressing solutions, Error Detection & Correction solutions and Wireless Sensor Networks Solutions. It also has been observed that to refine the research area in the above mentioned fields we need more exhaustive literature survey therefore the literature survey will be continued till we completes the identification and finalization of typical area selection.

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