Republic of Yemen
Sana'a University
Faculty of Engineering
Electrical Engineering Department

الجمهورية اليمنية
جامعة صنعاء
كلية الهندسة
قسم الهندسة الكهربائية

IPv4 to IPv6 transition mechanism in a fixed environment: The case of Yemen

Abdulsalam Alkholidi, Sana'a University, Faculty of Engineering
abdulsalam.alkholidi@gmail.com

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Agenda:

- ❑ **Introduction**
- ❑ **IPv6 in Yemen: a short history**
- ❑ **Necessity of transition to IPv6**
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  - **- Scenario 1: Dual stack mechanism**
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- ❑ **Challenges and obstacles**
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Introduction -1

- ✓ IPv6 transition mechanisms have become an important issue for most Internet Service Providers (ISPs) to:
  - Expand IP address space
  - Increase Internet usage -> increasing demand for IP addresses
  - Introduce new services for customers
  - Use the Smart Home Platform.
- ✓ Action plan for the deployment of IPv6 in Yemen is slowly
- ✓ Transition mechanism in Yemen from IPv4 toward IPv6 needs more time to startup seriously
- ✓ Internet density in this country is considered as among the lowest in the Middle East

Introduction 2 - Motivation

- ✓ Explore the present status of internet in Yemen
- ✓ Propose scientific solutions based on series of simulations results
- ✓ Describe step by step of proposed transition scenarios
- ✓ Concentrate on analyzing performance proposed scenarios
- ✓ Discuss and share the transition scenarios with MENOG 16 experts
- ✓ Benefit IPv6 as a bigger address space
- ✓ Transition to IPv6 is not possible that quickly as the installed general network infrastructure is IPv4 based
- ✓ Demand co-existence of them and integration between them for a period of time until the process of migration is complete.

Introduction 3 - Internet usage and population statistics

Table (1). Internet usage and population statistics starting from 2000 until 2015.

Year	Users	Population	% Pen.	GDP p.c.*	Usage Source
2000	15,000	17,900,000	0.1 %	US$ 410	ITU
2001	100,000	19,600,009	0.5 %	US$ 500	ITU
2005	220,000	20,764,630	1.1 %	US$ 550	M. of T
2009	370,000	22,858,238	1.6 %	US$ 550	ITU
2010	420,000	23,495,361	1.8 %	US$ 1,274	ITU
2013	2, 607, 000	24,410,100	10.7%	US$ 1,330	WB
2014	3,240,000	25,000,000	13%	~ US$ 1,422	Forecast
2015	4,200,000	25,100,000	16.733	Decrease*	

Source: IMF, World Bank, ITU, Gov. Reports./ * due to the complicated political situation in the country.

IPv6 in Yemen: a short history

Public Telecommunication Corporation (PTC) has taken the following actions:

- Formation a national team responsible for drawing the roadmap to move in to IPv6 (YEv6TF)
- Establishment national project to move in from IPv4 to IPv6 (2016 - 2017). **Time required: 16 months.**

Four phases for IPv6 transition mechanism proposed:

Phase I: Preparation to transition mechanism (Time required four months)

The surrounding environment to create transition:

A. Differentiate of a specialized laboratory for training and testing IPv6.
B. Book additional addresses of IPv4, IPv6.
C. Active participation in local, regional and international events relevant affairs online.
D. Organize workshops to illustrate the importance of the transition mechanism plan to IPv6.
E. Do action compatibility tests for operating devices with IPv6 protocol.
F. Prepare international access configuration with the world's suppliers.
G. Develop supportive policies to TM as adaptation with imported techniques.
H. Encourage networks operators in Yemen to start transition mechanism towards IPv6.

IPv6 in Yemen: a short history cont.

Phase 2: for both IPv4 and IPv6 Dual-boot (time required 6 months)

a. Dual operating in vertebrate network of the institution.
b. Services preparation (DHCP, DNS, Web, etc).
c. Create tunnels channels for who want to start transition mechanism to IPv6.

Phase 3: Publicize IPv6 features and benefits to internet operators and customers (time required 6 months)

Phase 4: Ongoing in TM until arriving to all IPv6 Networks.

Prefix	Description	First/Last announcement
2a02:2718::/29	Public Telecommunication Corporation Public Telecommunication Corporation AS12486 annoucement for PTC-YEMEN-IPv6-Block	
2a02:2718::/32	Public Telecommunication Corporation	2014-10-12
2a02:e280::/29	Daniel Rieger trading as "ONEnet" Daniel Rieger trading as "ONEnet"	
2a05:3380::/29	Yemen Co. for Mobile Telephony (Sabafon) CJSC Yemen Co. for Mobile Telephony (Sabafon) CJSC	
2a05:7a40::/29	MTN Yemen CJSC MTN Yemen CJSC	
2a05:7d80::/29	Yemen Mobile Company, Public Yemeni Joint-Stock Company Yemen Mobile Company, Public Yemeni Joint-Stock Company	

IPv6 in Yemen: a short history cont.

IPv6 Deployment Status

For country: Yemen ▾ For type: All categories ▾ Filter

Yemen is scanned since 2011-10-27 and the last information is dated 2016-02-29. Return to Aggregated Results. Jump to the IPv6 allocated prefixes.
Leave the cursor over a green/orange box to have more information (MSS, MTU). Hoover the mouse over a red box to display the AS of the web site (this is usually a good indication of the web hoster).
Click on any graphs or maps to zoom on it.
You can add a widget on your own web site with your country IPv6 status or get more geographical maps, click here to see how ;-)

: this site participated at the World IPv6 Day in 2011.

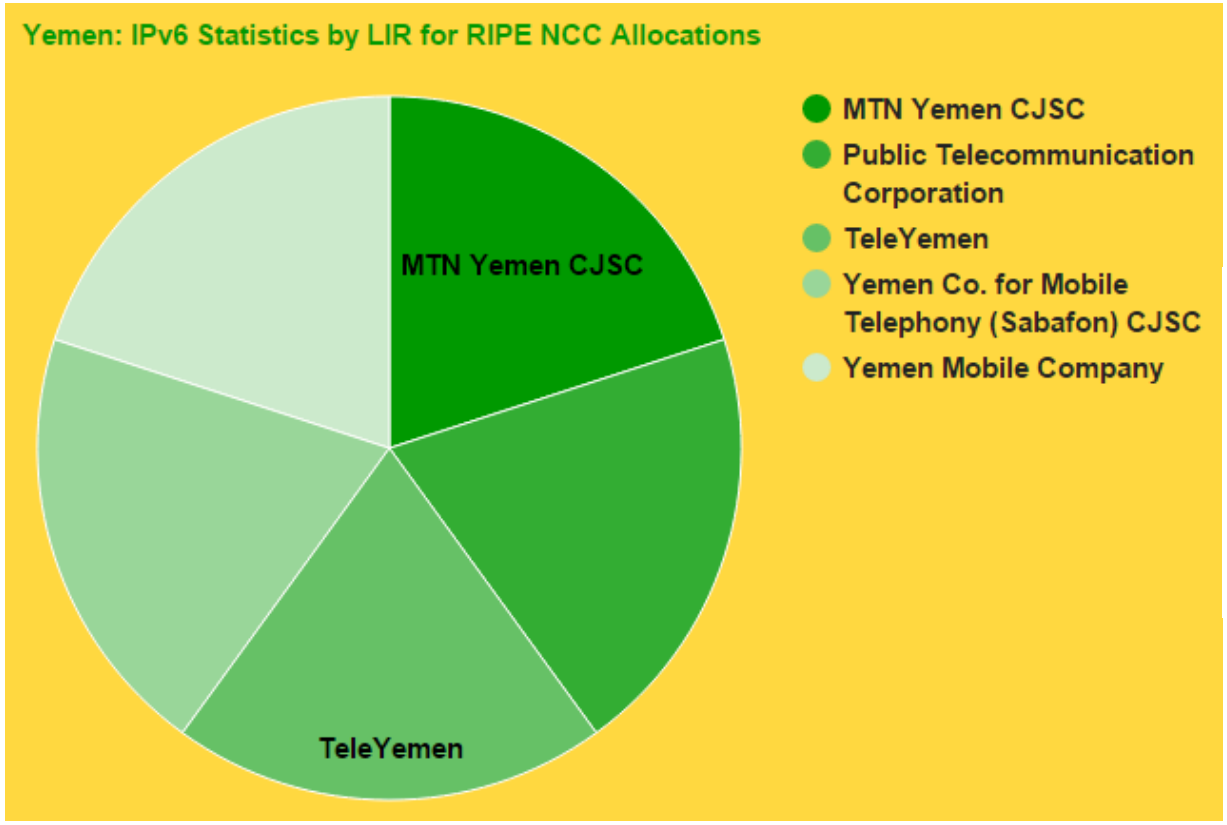
: this site has removed the IPv6 access after the World IPv6 Day (fear?).

Name	Alexa	Web	Mail	DNS
yemen.net.ye More whois	1/19380	www.yemen.net.ye 2a02:2718:4:2::70 2016-02-11	mail2.yemen.net.ye 2a02:2718:4:2::36 2016-02-17	ns2.yemen.net.ye 2a02:2718:4::34 1/4 2016-02-29
mocsi.gov.ye More whois	2/254340	FAILED	mail1.yemen.net.ye 2a02:2718:4:2::38 2016-02-17	ns2.yemen.net.ye 2a02:2718:4::34 1/4 2016-02-29
teleyemen.com.ye whois	3/278587	FAILED	FAILED	FAILED
amanaedu.gov.ye More whois	4/376745	FAILED	mail1.yemen.net.ye 2a02:2718:4:2::38 2016-02-17	ns2.yemen.net.ye 2a02:2718:4::34 1/2 2016-02-28
y.net.ye whois	5/487511	FAILED	FAILED	FAILED
			mail2.yemen.net.ye	

IPv6 in Yemen: a short history cont.

RIPE NCC Allocations

Zone	Statistics		
RIPE NCC	IPv4 Statistics	IPv6 Statistics	
Yemen	IPv4 Statistics	*IPv6 Statistics*	Allocations



Yemen (YE) - IPv6 address statistics (in /32 blocks) - Sorted by number of addresses

Data from RIPE NCC website as of: Mon Feb 22 2016
Total number of addresses: 40

Sort by number | Sort in alphabetical order

Rank	Local Internet Registry	Code	Number of addresses	Percentage	LIR Info
1	MTN Yemen CJSC	ye.mtn-yemen	8	20.000 %	RIPE Info
1	Public Telecommunication Corporation	ye.ptc	8	20.000 %	RIPE Info
1	TeleYemen	ye.ynet	8	20.000 %	RIPE Info
1	Yemen Co. for Mobile Telephony (Sabafon) CJSC	ye.sabafon	8	20.000 %	RIPE Info
1	Yemen Mobile Company, Public Yemeni Joint-Stock Company	ye.ym	8	20.000 %	RIPE Info

Necessity of transition to IPv6

- ✓ IPv4 addresses in Yemen are finished in 2012 and Yemen Net is obligated to pay supplementary IPv4 addresses from international market.

- ✓ Internet density in this country is considered as among the lowest in the Middle East

[Why Yemen can not deploy the IPv6 rapidly?]

- Complicated political situation in the country
- Low economic development
- Bad infrastructure
- Fixed-lines services unreachable for majority people.

IPv4 Address Report

This report generated at 28-Feb-2016 08:18 UTC.

IANA Unallocated Address Pool Exhaustion:
03-Feb-2011

Projected RIR Address Pool Exhaustion Dates:

RIR	Projected Exhaustion Date	Remaining Addresses in RIR Pool (/8s)
APNIC:	**19-Apr-2011** (actual)	0.5981
RIPE NCC:	**14-Sep-2012** (actual)	0.9304
LACNIC:	**10-Jun-2014** (actual)	0.1017
ARIN:	**24 Sep-2015** (actual)	
AFRINIC:	**04-May-2018**	1.6931

Necessity of transition to IPv6 cont.

Internet penetration in Yemen:

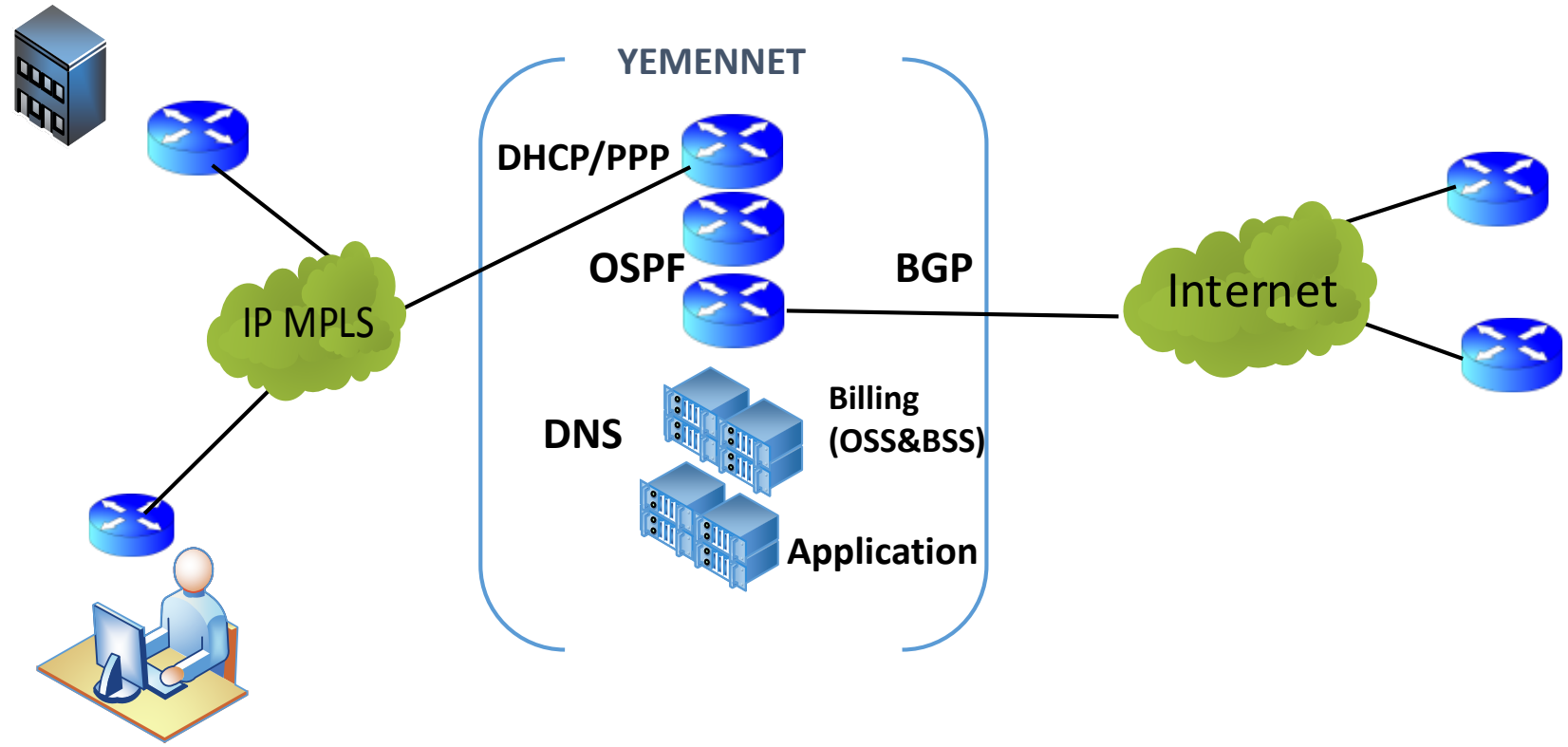
The internet penetration is so limited in Yemen until nowadays compared to neighbor countries for several raisons, most reported:

- Missing short-term and long-term plans (bad planning)
- Bad infrastructure
- Legacy administration and management.
- Bad marketing.
- Monopoly internet market for fixed environment.

IPv6 Transition mechanism: Proposed scenarios

- ✓ The transition mechanisms are one of the best solutions to makes IPv6 and IPv4 Networks run in the same infrastructure.
- ✓ IPv4 to IPv6 several transition mechanisms have been developed for according to different organization needs
- ✓ We will discuss and compared between dual stack, ISATAP, 6to4, GRE, Teredo, 6RD and NAT-PT.
- ✓ Each mechanism have their own advantages and disadvantages in different infrastructure.
- ✓ The IETF has defined a number of specific mechanisms to assist in transitioning to IPv6:
    - **Dual stack**
    - **Translation**
    - **Tunneling**
- ✓ An IPv6 transition mechanism is a technology that facilitates the transitioning of the Internet from the Internet Protocol version 4 (IPv4) infrastructure in use since 1981 to the successor addressing and routing system of Internet Protocol version (IPv6)

IPv6 Transition mechanism: Proposed scenarios cont.



Network Operators and ISPs | Governments | Business and Enterprise | Internet Users

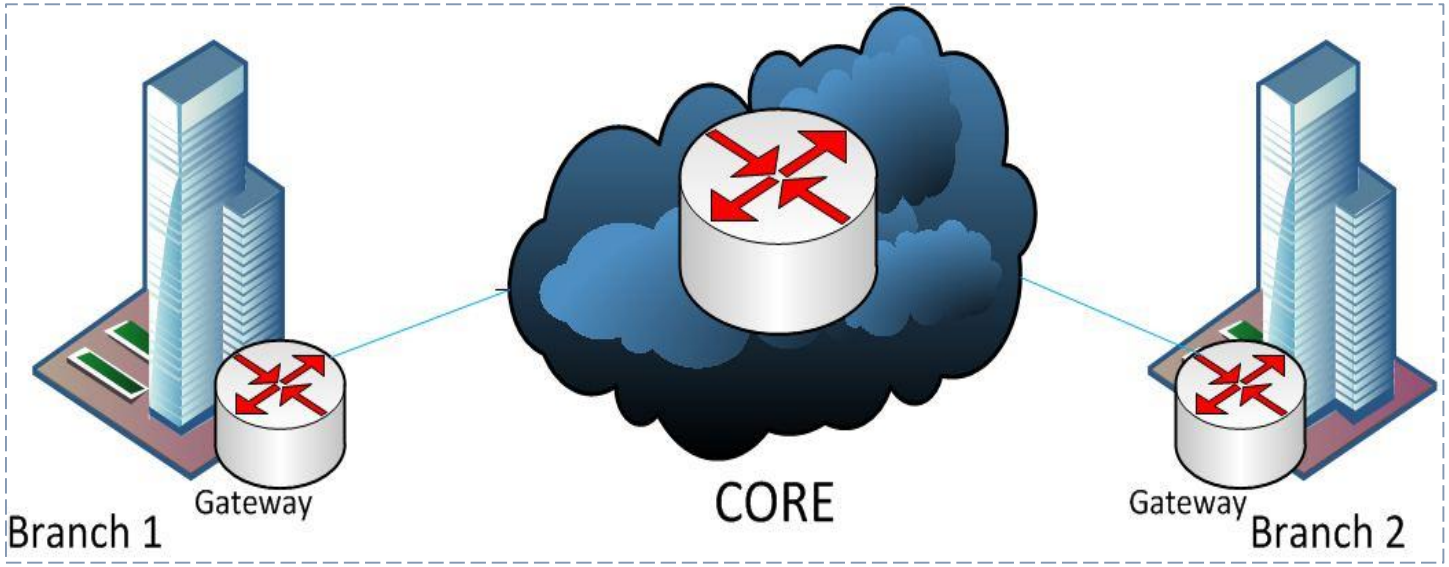
IPv6 Transition mechanism: Proposed scenarios cont.

IPv6 proposed transition scenarios:

- ✓ Evaluation process for existing internet network is considered as a bridge from IPv4 to IPv6.
- ✓ Existing legacy network theoretically has exceed the end of life (EOL) and all IP addresses space have been exhausted since several years
- ✓ **Consequence**, start planning and implementing IPv6 is recommended immediately for this case study.
- ✓ Several transition mechanism exist nowadays and there are many protocols that will be used in the transition from IPv4 to IPv6
- ✓ Three IPv6 transition mechanism are proposed in this study:
  - Dual stack deployment;
  - Protocol translation (STATIC NAT-PT);
  - Tunneling.

IPv6 Transition mechanism: Proposed scenarios cont.

Simple design of network architecture for ISP

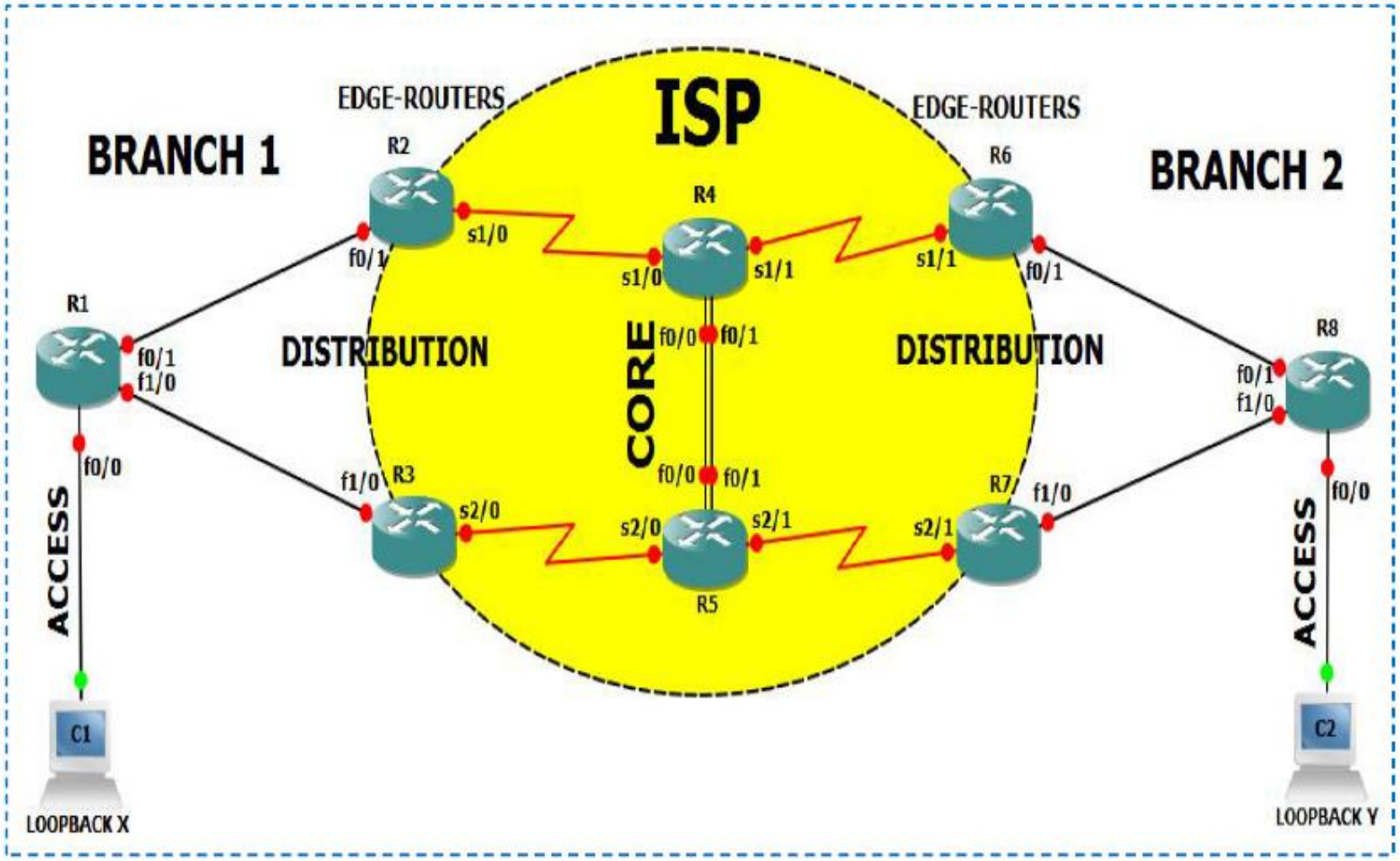


Network architecture of (ISP).

To design two branches of any operator or governmental offices connected to the ISP core or Head Quarter (HQ), which includes the core network, distribution, and access. The core network or ISP of Yemen Net has mainly six routers with other distribution routers at the edge.

IPv6 Transition mechanism: Proposed scenarios cont.

IPv4/IPv6 Transition Network (Emulation Diagram):



Tools Used:

- GNS3 version 0.8.4.
- Wireshark version 1.8.4.
- Packet Tracer 6.0.1.0011.
- Microsoft Visio 2010.
- Jperf 2.0.2.
- Virtual Box 4.2.1.

Routers: Cisco 7200 series with Cisco IOS version 12.4(4) T1.

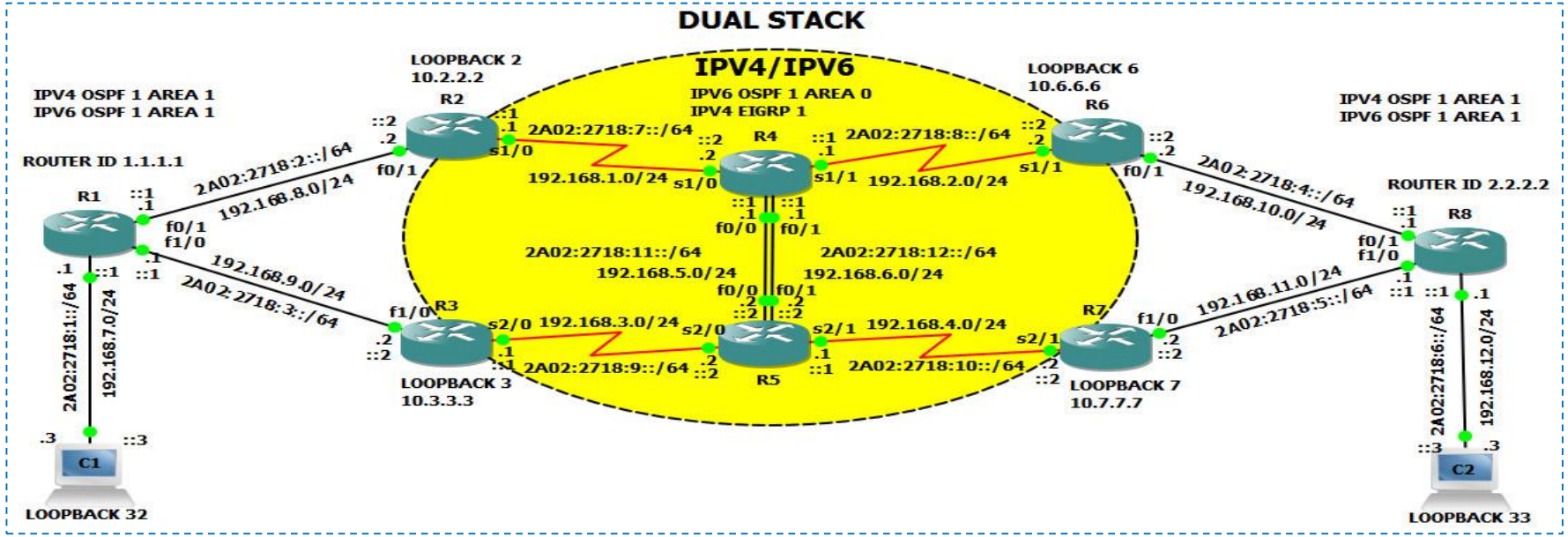
Client: Microsoft Loopbacks in Windows 7 and 8 with IP Dual Stack installed.

IPv6 Transition mechanism: Proposed scenarios cont.

Scenario 1: Dual stack mechanism:

Dual stack IPv4/IPv6 backbone needs:

- My require IPv4-IPv6 hardware forwarding.
- Memory size for IPv4 and IPv6 routing tables.
- Should IPv4 and IPv6 route to a single dual-stack edge router the same.
- IPv4 and IPv6 traffic should not influence each other.
- Different routing protocols for IPv4 and IPv6.
- Dual stack deployment option IPv4/IPv6 topology for related case study is presented in the following figure:

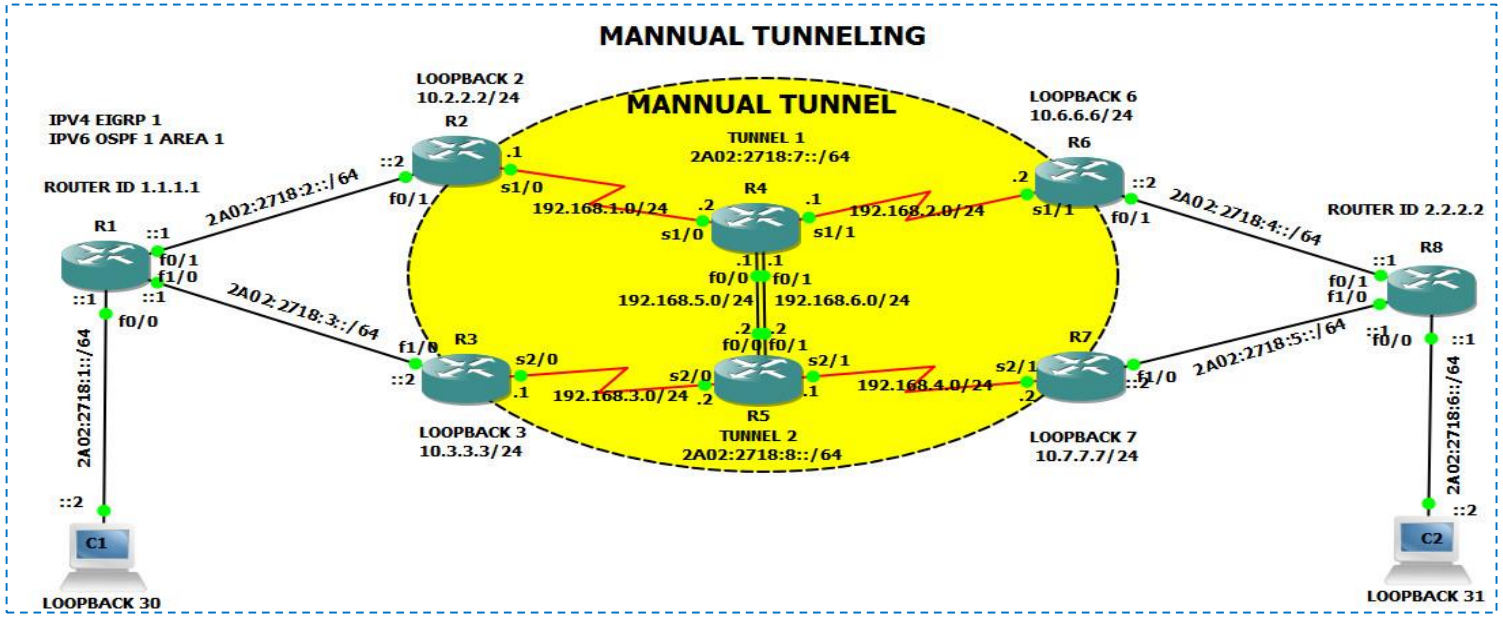


Dual stack mechanism topology.

IPv6 Transition mechanism: Proposed scenarios cont.

Scenario 2: Tunneling mechanism:

- ✓ Isolated IPv6 networks are connected over an IPv4 infrastructure using tunnels.
- ✓ The edge routers are the only ones that need to be dual-stacked.
- ✓ For IPv6, tunneling is an integration method in which an IPv6 packet is encapsulated within IPv4.
- ✓ This enables the connection of IPv6 islands without the need to convert the intermediary network to IPv6.
- ✓ Tunnels can be either manually or automatically configured, depending on the scale required and administrative overhead tolerated.

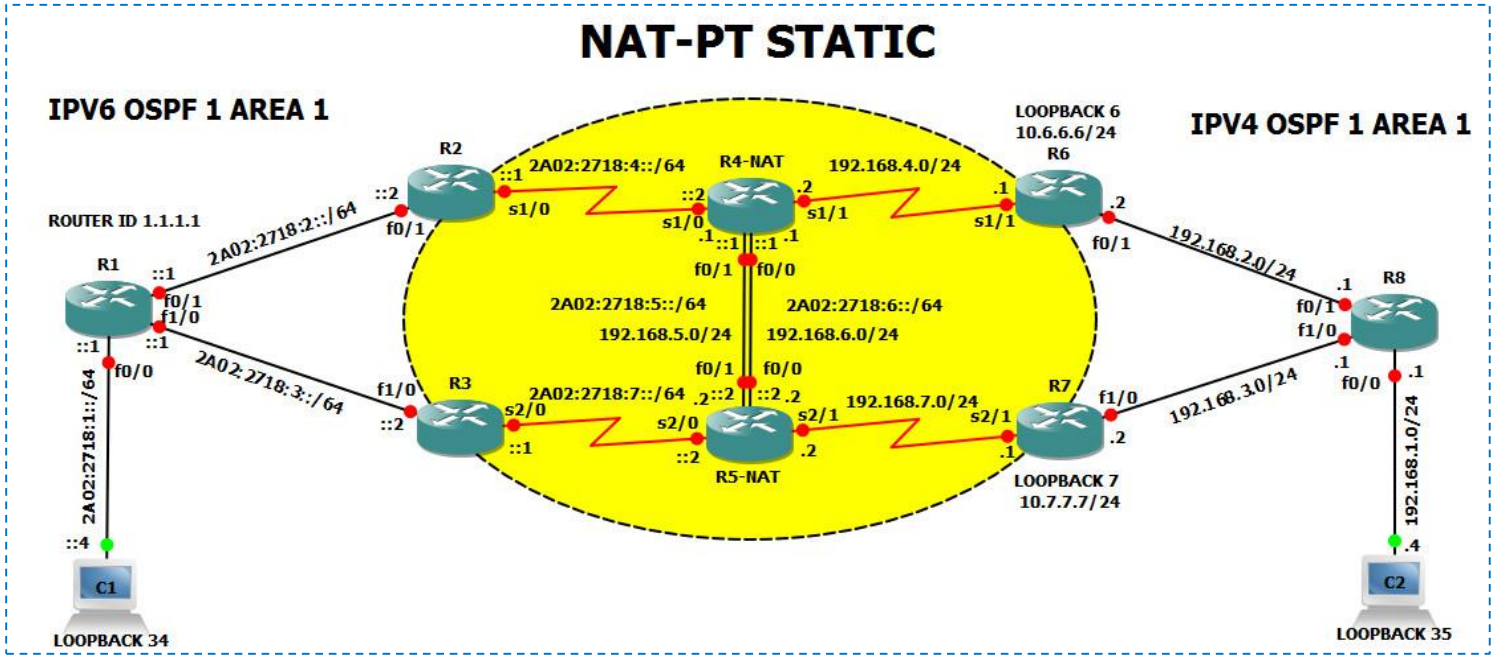


Tunneling mechanism topology.

IPv6 Transition mechanism: Proposed scenarios cont.

Scenario 3: Static NAT-PT Mechanism:

- ✓ Dual stack and tunneling techniques manage the interconnection of IPv6 domains.
- ✓ NAT-PT is an extension of NAT techniques and it provides protocol translation services for legacy equipment
- ✓ Cannot be upgraded to IPv6
- ✓ For some deployment scenarios or we can use NAT64 in this case to provide connectivity over native IPv6 to customers while letting them access IPv4

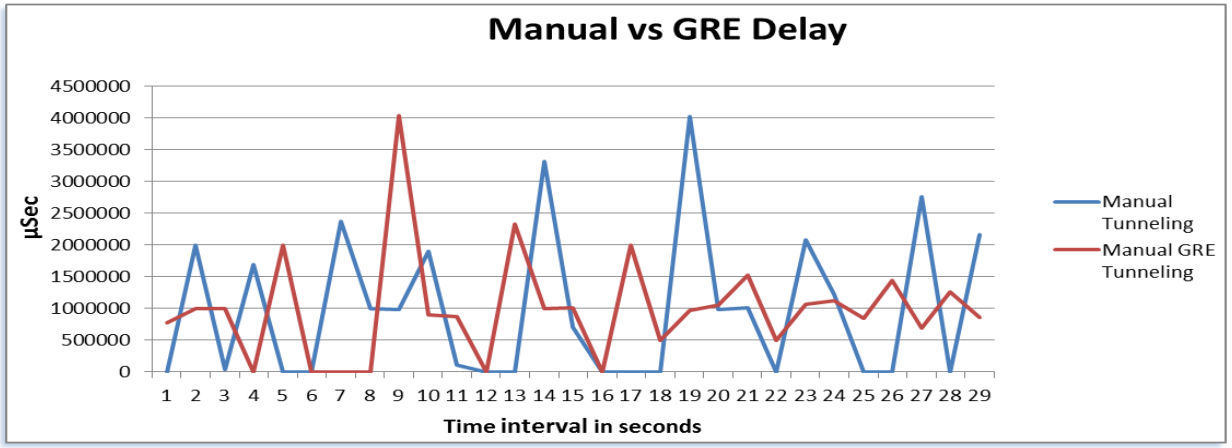


Static NAT-PT mechanism topology.

Simulation results and discussion (1)

- ✓ After having illustrated implementing and testing steps of IPv6 transition scenarios for proposed case study successfully
- ✓ We return to analyze the performance of each scenario separately
- ✓ Series of simulation results carried out in order to validate our approach and to introduce its features.
- ✓ Evaluated the following parameters: **Delay, Throughput, Jitter, Bandwidth, Packet loss, Latency** and other network features using wireshark as it companion with GNS3.
- ✓ Measuring, the performance of any computer or telecommunication networks should be tested the indicated parameters previously:

  - **Delay:** The delay is the amount of time the packets must wait for something happen in the path like congestion



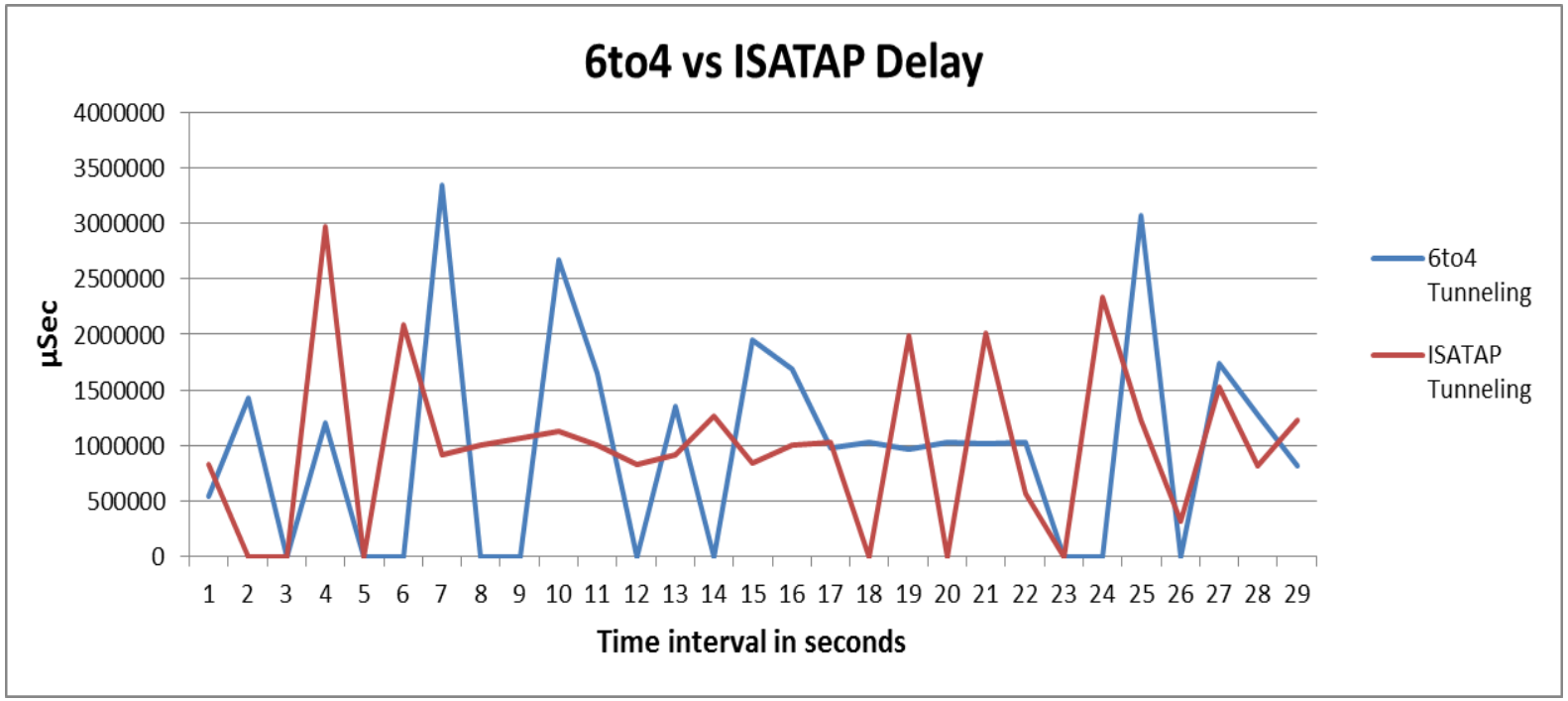
Manual versus GRE delay.

This Fig. summarizes the obtained results of manual versus GRE delay in seconds for manual and manual GRE tunneling. The obtained two curves show that the GRE tunnel is better than manual one.

Simulation results and discussion (2)

Delay

The following figure shows the curves to compare between automatic tunnels of 6to4 versus ISATAP delay. We notice that the ISATAP tunnel is better than 6to4 tunnel.

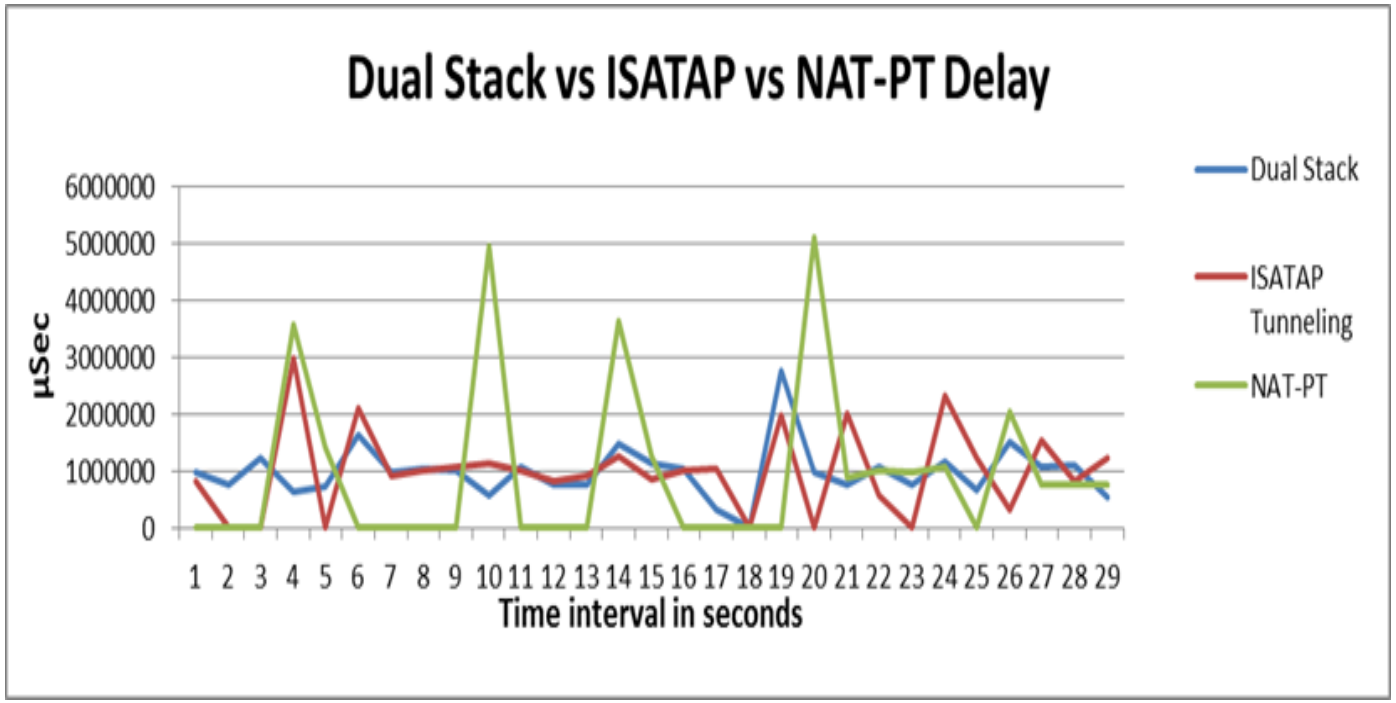


6to4 versus ISATAP Delay.

Simulation results and discussion (3)

Delay

The third comparison is between dual Stack, ISATAP, and NAT-PT mechanisms: the curves demonstrated in Fig. 7 show that the dual stack has some advantages over ISATAP and NAT-PT.



Dual stack, ISATAP, and NAT-PT delay.

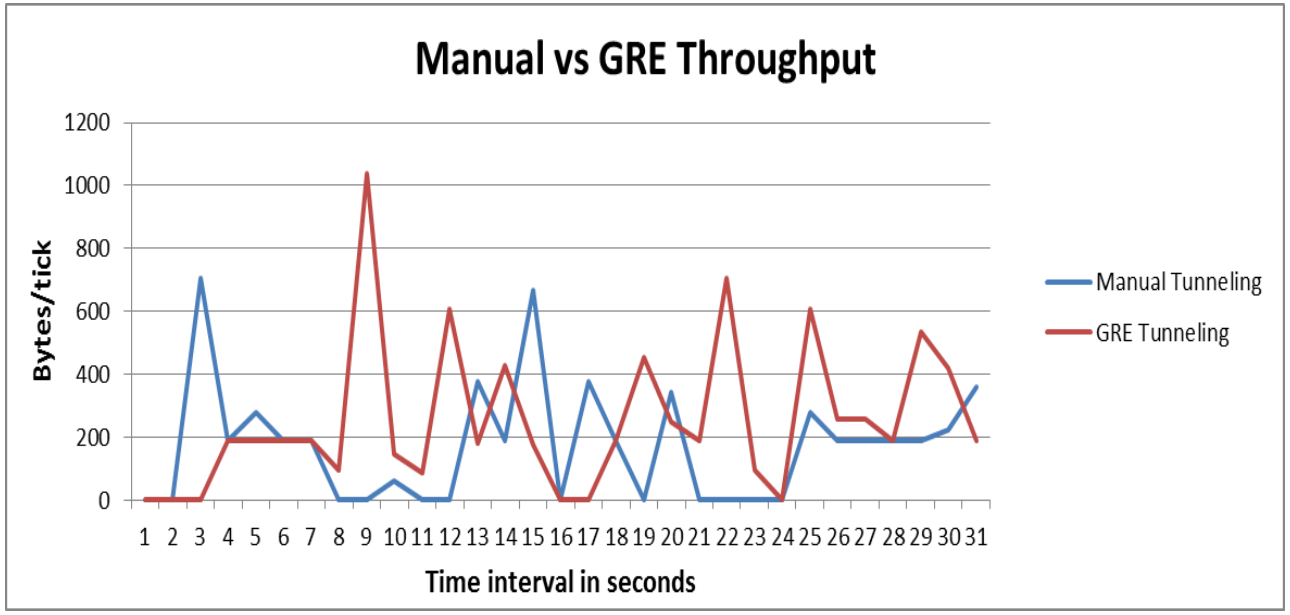
Simulation results and discussion (4)

Throughput: Network throughput is the rate of successful message delivery over a communication channel.

It represents the average number of bits successfully received or transmitted by the receiver or transmitter channel per unit time, in bits per second.

Following three figures introduce manual versus GRE throughput, 6to4 versus ISATAP throughput, and dual stack, ISATAP, and NAT- throughput, respectively.

First step shows the manual versus GRE throughput, we note that the GRE tunnel is better than manual one

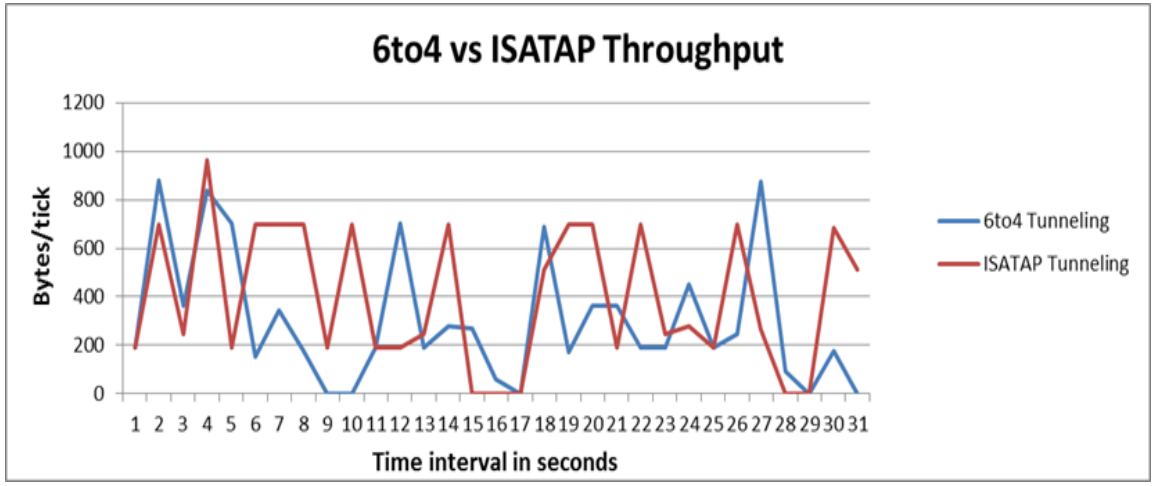


Manual versus GRE throughput.

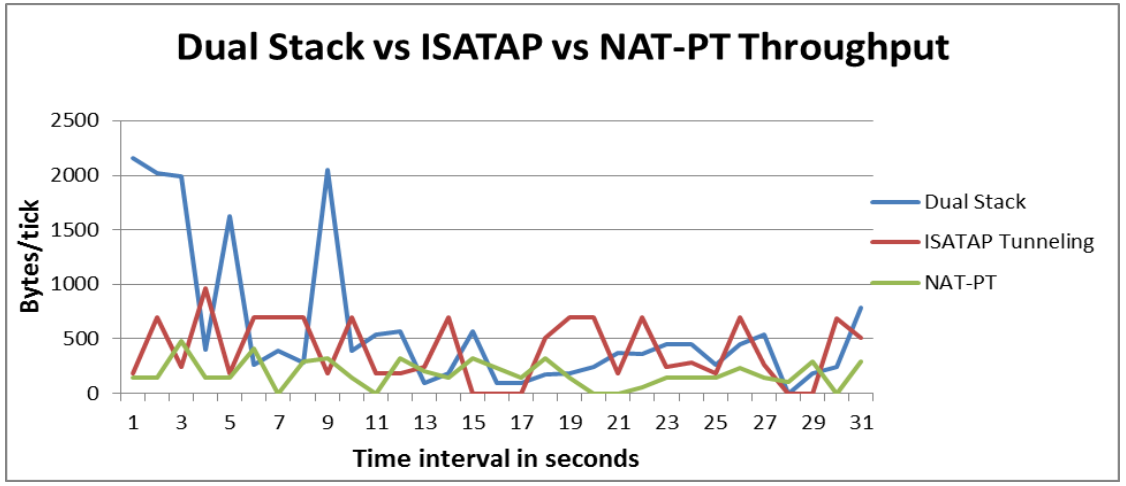
Simulation results and discussion (5)

Second step explores 6to4 versus ISATAP throughput between automatic tunnels; we note that the ISATAP tunnel shows better time interval in seconds (blue curve) over 6to4 tunnel (brown curve)

Third step shows dual stack, ISATAP, and NAT-PT throughput, the results show that the dual stack (blue curve) is absolutely the best over ISATAP tunneling (brown curve) and NAT-PT (green curve)



6to4 versus ISATAP throughput.



Dual stack, ISATAP, and NAT-PT throughput.

Simulation results and discussion (6)

Jitter and latency: Jitter refers to the variation in the packet arrival time. It is definitely clear that dual stack approach is the best for solving the transition mechanism process.

- ✓ Some disadvantages like the large resources are needed to deal with two different types of protocols at the same time.
- ✓ The following Table (2) shows a very small jitter about 0.06ms, which is barely noticeable compared to other techniques.

Table (2). Jitter and latency in each mechanism.

Technique /parameter	Jitter in (ms)	Packet sent	Packet received	Lost packets	Average RTT in (ms)
Dual stack	0.06	100	97	3%	215
Manual tunnel	3.02	100	90	10%	231
GRE tunnel	3.26	100	83	17%	233
ISATAP tunnel	3.17	100	87	13%	295
6to4 tunnel	7.42	100	89	11%	317
Static NAT-PT	15.97	100	93	7%	223

Challenges and Obstacles

- Awareness
- Properness & Compatibility
- Regulator
- Time
- Complicated Country Situation
- Outage and instabilities.

Conclusions

- ✓ Explore the depth study for existing and future Yemen Net is illustrated in this paper.
- ✓ Illustrate three transition mechanisms are implemented, tested and evaluated its performance based on series of simulation results.
- ✓ Compare between different obtained results
- ✓ Deduct that dual stack transition mechanism is the most common and straightforward
- ✓ Prove that the dual stack is suitable for ISPs, enterprises networks as well as home users
- ✓ Continuous training graduate students in Yemeni Universities.
- ✓ Increase the cooperation with RIPE.
- ✓ Create training center to train Yemeni engineers and reclamation of the IPv6 features.

Questions?

Contacts:
abdulsalam.alkholidi@gmail.com
https://www.researchgate.net/profile/Abdulsalam_Alkholidi

References:

- http://www.internetworldstats.com/me/ye.htm
- Anders Henten and Reza Tadayoni, "Transition from IPv4 to IPv6“. 23rd European Regional ITSConference, Vienna,"Austria, 2012.
- http://en.wikipedia.org/wiki/IPv6.
- Ramy Khaleel Ahmed, "Transition Mechanisms From IPv4 to IPv6". Dissertation, Baghdad, University - College of Science, 2013.
- John J. Amoss and Daniel Minoli, "Handbook of IPv4 to IPv6 Transition". Methodologies for Institutional and Corporate Networks, Auerbach Publications, Chapter 6, 2008.
- Daniel Minoli and Jake Kouns, "Security in an IPv6 environment". Auerbach Publications, text book, 2009.
- Implementing Cisco IP Routing (ROUTE) Foundation Learning Guide.
-Ciprian Popoviciu et al., "Deploying IPv6 Network", Chapter 8: Implementation IPv6 in the Enterprise Network. CCNP ROUTE: Implementing IP Routing, Cisco Press, 2007-2010.
- Sezen Yeşil (ICTA), ICT Specialist and Onur Bektaş (ULAKBİM), Senior Researcher, "IPv6 Transition Works in Turkey and Experiences of ICTA". MENOG 7, Istanbul, Turkey, 23 October 2010.
- http://www.ipv6.ye/
- http://www.carduel.ru/series/YEV6
- http://www.potaroo.net/tools/ipv4/
- http://inetcore.com/project/ipv4ec/index_en.html
- https://en.wikipedia.org/wiki/IPv6_transition_mechanism
- https://www.vyncke.org/ipv6status/detailed.php?country=ye#prefixes
- https://www-public.tem-tsp.eu/~maigron/RIR_Stats/RIPE_Allocations/IPv6/ByNb/YE.html