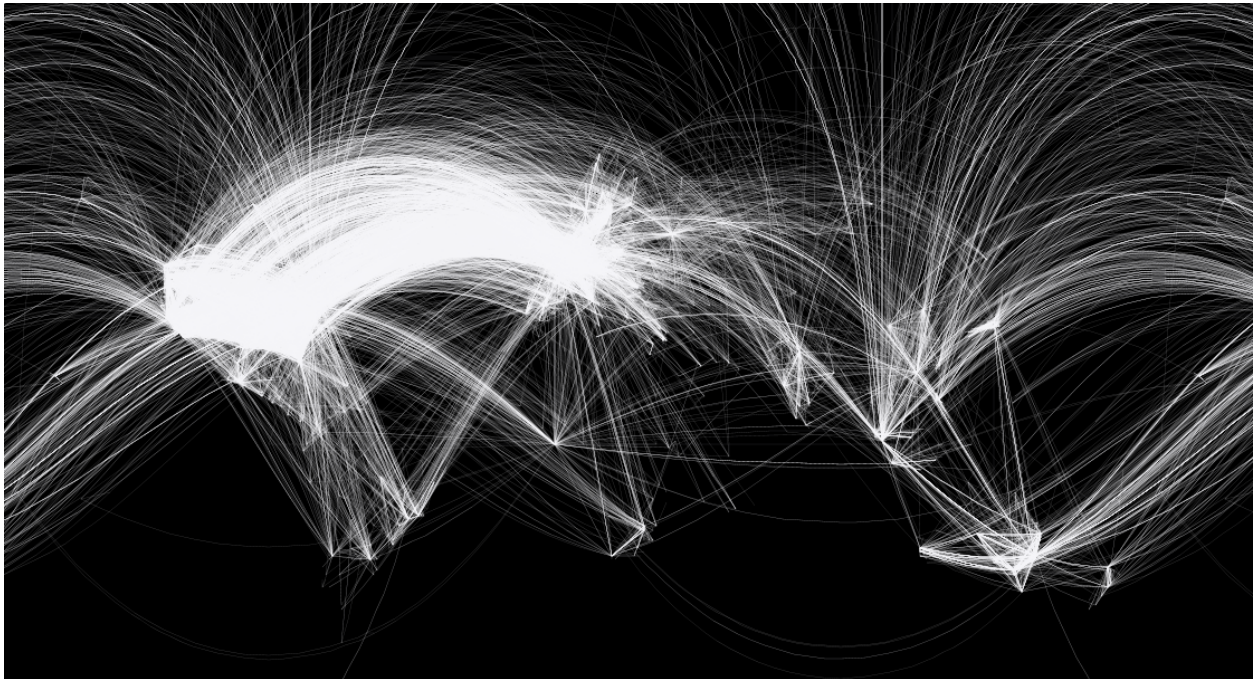# Integrating IPv6 into the CPE464 Lab Curriculum

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Title Image   A map of the IPv6 world. The image is a result of mapping the connections between the one hundred thousand most central IPv6 nodes on the Internet.

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1 Introduction

The Internet Protocol version 4 was standardized in 1981 by DARPA, a division of the Department of Defense focused on developing cutting-edge technologies. The protocol — designed to connect every computer on the globe — could address roughly 4 billion hosts, a number which seemed unbelieveably immense compared to the 200 or so computers on the Internet at the time.

On the 4th of July of this year the American Registry for Internet Numbers, which assigns Internet addresses ("IP addresses") is predicted to exhaust its remaining IP addresses. Registries in Asia and Europe have already run out of their share of the "address space". A replacement protocol, version 6, was approved in 1998. The protocol laid dormant for most of the 2000s, but the fast-approaching deadline has spurred its adoption. Figure 1 shows the skyrocketing IPv6 adoption rates. IPv6 is rapidly becoming relevant in both the consumer and enterprise sectors.
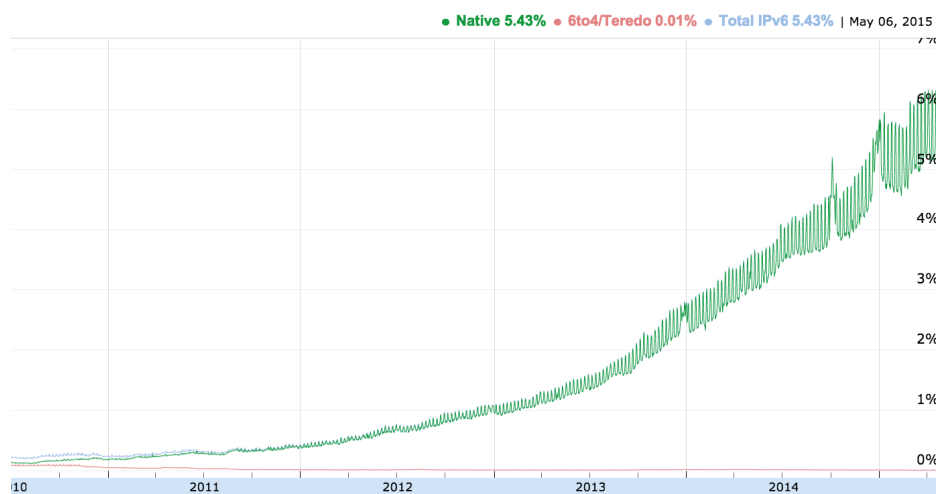

Figure 1: Percentage of users accessing `www.google.com` over IPv6

Cal Poly students taking CPE464, Introduction to Computer Networks, will learn IPv4 in depth. In their lab section, which accompanies the lecture, they will implement IPv4 on enterprise-grade networking equipment. The CPE464 lecture will also cover IPv6, but the lab will not. This report will present research about the best way to integrate the teaching of IPv6 into the CPE464 lab curriculum.

This research can be broken into two parts. The first will address networking technologies that implement IPv6. The second will investigate various ways to integrate these technologies into the existing lab curriculum. This report will then select the optimal option from each and combine them to form a lesson plan, a recommendation on what technology to use and how to use it in the CPE464 lab.

The *Methods* section of this report will summarize the areas of research that were looked into and what specific sources were researched in those areas. The *Results* section will then present the research findings from each of the methods. The *Conclusion* and *Recommendations* sections will

then detail an the best course of action derived from the research. Finally, a *Glossary of Terms* will provide definitions for any unfamiliar terms used in this report.

2   Methods

In the course of researching this report I split the problem at hand, of how best to teach the concepts of IPv6 to CPE464 lab students, into two questions. The first: "What technologies best show how IPv6 is different from IPv4?" The second: "What is the best way to integrate these technologies into the CPE464 lab curriculum?" Correspondingly, I used two different methods of research, using the findings from each method to answer one of the two questions.

These two questions can be categorized respectively as a technical question and a pedagogical question. To answer the technical question I consulted internet research and to answer the pedagogical question I interviewed Dr. Hugh Smith. These two methods are further detailed in the two subsections below.

2.1   Interview with Dr. Hugh Smith

I interviewed Dr. Hugh Smith to find an answer to my second question. Dr. Smith is the professor currently teaching the CPE464 lecture and lab sections (he is also the main recipient of this report.) As one of the co-authors of the lab curriculum, Dr. Smith is qualified to access which methods of presenting new lab material will be the most effective, and how they will meet the lab's unique constraints.

My aim in talking to Dr. Smith was to determine exactly that: how the current CPE464 lab is structured, and how various IPv6 technologies might be integrated with the current labs. During the interview Dr. Smith suggested several different strategies to accomplish this, and detailed their pros and cons.

2.2   Secondary Research

I conducted secondary research online to answer my first question. I read several online manuals and briefs about various technologies that used IPv6 in a significant way. The technologies had to have two requirements to be researched:

- Significant presence in either the existing lab curriculum or in consumer networking

- An existing and widely used IPv4 implementation

These requirements were to ensure that lab users would not be too unfamiliar with the new lab material, and so that old material could be used a template when writing new lab manuals and other documentation.

2.2.1   Cisco: "IPv6 Tunnel though a IPv4 Network"

IPv6 and IPv4 networks are incompatible, and as a result it is necessary to pass IPv6 traffic through IPv4 networks so that they can communicate in the absence of a direct link. This how-to guide details individual steps to accomplish this on Cisco iOS routers.

2.2.2   Cisco: "IPv6 Autoconfiguration"

IPv6 addresses are very long and cumbersome to enter manually. Thus the protocol includes a feature where computers running IPv6 can pick their own address based on pre-determined factors inherent to the system. This white paper explains the process and lists several drawbacks.

2.2.3   CircleID: "DHCP for IPv4 vs. IPv6"

This web article, intended for consumers, discusses how IPv6 addresses may be assigned through the Dynamic Host Configuration Protocol (DHCP). DHCP, optional in many IPv4 environments, is a crucial component of the new protocol.

2.2.4   Cisco: "RIP for IPv6"

Routers, devices which move network traffic between physical networks, can be configured to talk to each other automatically using the Router Information Protocol. This manual list comprehensively all the commands necessary to configure RIP for IPv6.

3 Results

To evaluate my secondary results I used my own knowledge as a T.A. for the CPE464 lab section, and a decision matrix that assigns objective value to the different technologies.

3.1 Interview with Dr. Hugh Smith

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3.2 Cisco: "IPv6 Tunnel though a IPv4 Network"

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3.3 Cisco: "IPv6 Autoconfiguration"

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3.4 CircleID: "DHCP for IPv4 vs. IPv6"

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3.5 Cisco: "RIP for IPv6"

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4 Conclusions

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5 Recommendations

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6 Glossary of Terms

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7 Works Cited

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