



Introduction to Python Network Automation Volume I - Laying the Groundwork

The Essential Skills for Growth

—

Second Edition

—

Brendan Choi

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To Mom and in remembrance of Dad,

Your boundless love and unwavering patience have been the true guiding lights, illuminating every step of this profound journey.

Within these pages, this book stands as a testament to the steadfast faith and unwavering encouragement you both have selflessly offered.

I am deeply thankful for the profound impact you've had on this endeavor.

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About the Author



Brendan (Byong Chol) Choi, serving as a highly accomplished tech lead at Secure Agility, brings over two decades of hands-on experience in the dynamic world of the ICT industry. He holds certifications in Cisco, VMware, Fortinet, and ITIL. Brendan has lent his expertise to prominent enterprises such as Cisco Systems, Dimension Data (NTT), Fujitsu, and more recently, leading Australian IT integrators like Telstra and NTT. His focus on optimizing enterprise IT infrastructure management and refining business processes sees him utilizing a diverse range of both open-source and proprietary tools. Beginning his journey in the trenches of Cisco TAC Frontline, Brendan

transitioned to pivotal IT engineering roles, navigating a spectrum of emerging and legacy technologies. Stemming from a traditional infrastructure background, he ardently explores emerging IT domains like the Cloud, IoT, DevOps, and the transformative technologies linked to the fourth industrial revolution. Brendan's literary contributions include *Python Network Automation: Building an Integrated Virtual Lab*, *Introduction to Python Network Automation: The First Journey*, and his primary work, *Introduction to Ansible Network Automation: The Practical Primer*. These works are crafted to resonate with and address the current enterprise IT landscape, sharing invaluable industry insights with the wider IT community. His legacy of training over 200 network and systems engineers in Python and Ansible Network Automation is complemented by his passion for disseminating industry-acquired knowledge through social media, blogging, and his YouTube channel. His curiosity spans across diverse domains such as private and public cloud, enterprise networking, security, virtualization, Linux, automation, and the transformative technologies driving the fourth industrial revolution. Amid a cacophony of disingenuous voices in the IT industry, "live by your words" remains Brendan's guiding principle. His unwavering dedication to enterprise infrastructure management echoes through his unwavering commitment to continuous learning, extensive knowledge sharing, and his profound contributions to the rich ICT world.

About the Technical Reviewers

Boyd A Tweed has been in networking for 15 years, working in all types of industries with many different network devices, from a single site to multinational sites spanning the globe.

His passion for automation started when he was building a new data center around Cisco ACI. Trying to learn the new technology was very difficult, because it was unlike any other network device he had touched—everything was GUI based and there was no CLI in sight. He started learning Python to inject the configurations and quickly realized how much easier and faster it was to use programming. He learned everything he could, reading books, taking seminars, and going to classes. Automation really started to take hold of him when he was learning Netmiko to do simple, ad hoc commands. He saw the value in the ability to configure multiple devices from a single script. He hopes, by reading this book, you will gain a better understanding of automation and wishes you the best of luck on your automation journey.

Radhika Shitlani is a network professional with over eight years of experience in network design, implementation, and automation. She has been using Python and contributing to it since its inception in the network domain. She has extensive experience in automating network feature testing and building tools to automate daily tasks in network operations. Currently, she designs and automates networks in data centers of global cloud leaders.

An enthusiast, she is always striving to learn and upgrade her skills. Apart from automating things in Python, she enjoys adventure sports and has completed the first (beginner) level of flying training. She is currently undergoing scuba diving training and dreams of becoming a professional sea diver.

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I am deeply grateful to my IT industry mentors—Lesek Geba and Truyen Nguyen—and my former managers—Kai Schweisfurth and Ty Starr. Their extensive industry expertise and wisdom, amassed over 40 years in IT, have been invaluable in shaping the first and second editions of this book. My sincerest thanks to Justin (Cheol Yoon) Cheong for his invaluable guidance in the realm of authorship. I extend my deepest appreciation to all of them. My heartfelt thanks also goes to my wife, Sue, and our children, Hugh, Leah, and Caitlin. Their unwavering support has been my bedrock throughout the creation of this book. Their love and understanding have been my unwavering pillars. I also extend sincere gratitude to my extended family, friends, and colleagues for their steadfast support. Lastly, I want to express my gratitude to my readers for embarking on this incredible network automation journey with me.

—Brendan Choi, 2024

Introduction

Python’s integration into enterprise network administration has surged in popularity among leading IT organizations. It is increasingly recognized as a pivotal skillset for network engineers in a growing number of organizations, gradually revolutionizing the landscape of network administration and ICT (Information and Communications Technology) infrastructure management.

Written by an ICT expert for real ICT professionals, this book aims to distill core practical knowledge devoid of false assumptions. It’s founded on the belief that the book’s target audience enjoys hands-on learning approaches over pure theory. This book is not for talkers, idealists, or theorists who merely preach, but for those ready to act. The commitment here is to provide an authentic experience, guiding readers through the actual journey of acquiring network automation skills using Python and its encompassing technologies from scratch. Understanding that individuals in IT come from diverse backgrounds and varying skill levels, this book operates under the notion that its targeted readers are beginners of Python Network Automation. It encourages readers to build everything themselves for a firsthand, immersive experience, emphasizing the importance of holistic comprehension rather than a specialized approach in the enterprise IT and network automation ecosystem. In essence, this book operates on the principle that “seeing is believing!”

In its inaugural edition, *Introduction to Python Network Automation: The First Journey*, this book offered readers a structured path to establish a robust foundation in Python Network Automation. This second edition revisits the original, bolstering the structured learning path with additional new content. The original version was an invaluable resource for IT professionals and students aiming to enhance their automation skills. This revised edition represents a refined iteration, amalgamating five foundational books—Python, Linux, basic networking, essential virtualization, and enterprise networking lab-building techniques—across two comprehensive guides. Tailored specifically for networking students and IT engineers, it provides hands-on experience in constructing a Python Network Automation lab from scratch. With practical examples derived from actual enterprise infrastructure, this edition offers valuable insights into leveraging Python effectively within real enterprise network

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management scenarios. This book has been divided into two parts—*Part I: Laying the Groundwork: The Essential Skills for Growth* and *Part II—Stepping Up: Beyond the Essentials for Success*. This is Part 1 of the second edition.

While many resources delve into Python-based network automation, few adequately equip students and engineers for Python Network Automation within a comprehensive IT infrastructure management framework. The success of the first edition among genuine ICT professionals stemmed from this book's direct, relatable, and holistic approach to learning network automation using Python and related technologies. Unlike resources that promise a zero-to-hero journey but falter due to their narrow focus, this book stresses the interconnectedness of technologies within the enterprise IT ecosystem. Solely comprehending Python Network Applications focused on software programmability offers limited mileage; a broader perspective becomes essential.

Numerous network automation books tantalize with the allure of Python Network Automation without emphasizing the “no pain, no gain” reality. Conversely, this book adopts a genuine approach, immersing readers in an authentic experience that exposes them to the challenges of acquiring network automation skills using Python. Readers engage in installing and configuring nearly everything themselves, learning from mistakes, overcoming obstacles, and ultimately mastering essential IT skills. This journey empowers readers to overcome initial hurdles in Python Network Automation, fostering the resilience and proficiency necessary to develop functional Python network applications.

By engaging with this book, readers will gain valuable knowledge and well-rounded skills. The book offers a structured learning path, gradually building proficiency in Python and its encompassing technologies. It begins with essential Linux administration skills, progresses through Python basics pertinent to enterprise network automation, explores foundational enterprise network labs, delves into basic networking concepts, and culminates in integrating various technologies. Readers will develop real Python networking applications and optimize code in a production-safe environment—all achievable from a single laptop. Readers can learn, write, and test their Python applications without causing major outages to network services. This journey provides insights into streamlining enterprise network management processes, transitioning from manual tasks to semi- or full automation, thus enhancing efficiency and productivity. Throughout, I share my industry insights gained over the last two decades in the ICT industry, equipping readers with real working knowledge and essential skills to apply Python in network automation. This will empower readers to navigate the ever-evolving landscape of enterprise networking administration confidently.

Designed for diligent readers seeking to enhance their network automation skills with Python, this book caters to IT students, network engineers, and developers managing IP services, networking devices, servers, cloud, and data centers. Technical leaders implementing network automation, mentors training team members, instructors teaching network automation, and Cisco Network Academy students pursuing network administration certifications will also find value in its pages. It's tailored to those interested in integrating network automation into their development process, offering practical knowledge across their enterprise network. Leveraging Python, it effectively teaches network automation techniques and encompassing technologies.

Come along on this expedition with me to enhance your network automation skills and discover new horizons in managing enterprise networks.

CHAPTER 1

Introduction to Python Network Automation

This chapter introduces the book by starting with a casual discussion of the experience of working as an IT professional in today's IT landscape. It then roughly defines the major IT domain groups to which Enterprise IT engineers belong, discusses their responsibilities and required skillsets, and compares their strengths and weaknesses. The chapter also outlines a study plan that serves as the backbone of the book. From the perspective of a working ICT engineer, the chapter considers the importance of learning a programming language and understanding software development, specifically Python within DevOps. Python within DevOps is the primary interest of the readers and core topic of this book, as it kickstarts the reader's journey into network automation. Lastly, the chapter provides information about the minimum system requirements needed to build a fully working Python/Linux/network automation ready-to-use lab on a single laptop/PC, along with the recommended software set for installing virtual devices, such as Linux servers, routers, and switches.



***Aiding your journey:** The highlighted number indicates the chapter's difficulty, for guidance only.*

Laying the Foundation

In recent years, network programmability has been revolutionizing the enterprise networking industry, with network automation at the forefront for the past decade. Companies and organizations that once spent millions of dollars on traditional IT lifecycle management are now seeking new frameworks that provide faster, more cost-effective, yet more reliable and predictable network operations. However, many engineers working in the field are still encountering difficulties when trying to embrace network programmability and automation concepts. Reflecting on my journey, I understand that embracing and adopting automation concepts can seem daunting at first—it's like trying to board a moving train or trying to climb Everest. However, with the right resources and guidance, engineers can effectively overcome initial difficulties and master the basic skills needed to excel in network automation.

Jumping on the network programmability bandwagon can be intimidating, especially if you have no prior programming experience or are new to network automation or software-defined networks. It can feel like climbing a mountain—even after reaching the first peak, you realize that an even taller mountain awaits. As a network engineer, you may be comfortable with traditional network administration methods, but now your bosses expect you to upskill and automate your manual tasks with code. If you refuse, someone else will write the code, and you risk losing credibility.

To succeed in network programmability, you must step out of your comfort zone and embrace the learning curve to get up to speed. While it may seem like uncharted territory, with the right resources and determination, you can master the skills needed to excel in network automation. Don't let fear hold you back; Willy Wonka's golden ticket to the automation bandwagon could be on the other side of the mountain. No one can force you to embrace the journey, but extending your career in this cutting-edge industry requires a willingness to explore unfamiliar territory and acquire new skills.

In this opening chapter, I guide you through your first steps into Python Network Automation. Whether you're new to network automation or already on your journey but feel like you're not making progress, this book is for you. I start by identifying the three primary information technology (IT) domain groups that exist in today's IT landscape. Defining the skillsets possessed by each group will give you a clue about where to begin your journey. Through a comparison of these skillsets, I conduct an unbiased gap analysis to determine the strengths and weaknesses of each group. This book is written from the perspective of the enterprise network industry by an experienced network engineer. Additionally, it has been technically reviewed by two Cisco Network Academy

Instructors to ensure the topics remain relevant to real network engineers' work. The goal is to help you develop a realistic learning strategy that enables you to close any identified skill gaps and grow into a cross-functional engineer. As a cross-functional engineer, you will possess strong networking skills, the ability to manage Linux operating systems, and the capability to write code to automate Python applications. This shift will allow you to move away from mundane and repetitive tasks.

Moreover, I introduce you to the concept of a *hybrid engineer*—a cross-functional engineer who is in high demand in the current and future IT job markets. I discuss how the career knowledge growth for such hybrid engineers takes the shape of a “T.” The shape of an engineer’s career growth mindset can dictate their career path and be the deciding factor for the initial IT domain selection, with the top of the shape representing the potential of an engineer’s skillsets and career growth. I have observed network and system engineers who have supported a single technology for over 30 years, content with their comfortable lives and stable jobs. However, technology is evolving rapidly, and manual-driven tasks are gradually being replaced by automated scripts and API-driven applications. Therefore, the new breed of IT engineers may not have the luxury of riding a job into their retirement based on what they learned 5 or 10 years ago.

Figure 1-1 depicts the technologies that are supported by “I-shaped”-minded engineers versus “T-shaped”-minded engineers. Look at the top of the letter—a picture is worth a thousand words. The question is, are you an I or a T? This is a genuine question that all IT engineers and students must ask themselves regularly to develop the best possible career paths. Of course, there is no right or wrong answer to this question, as everyone has different career aspirations and personal circumstances.

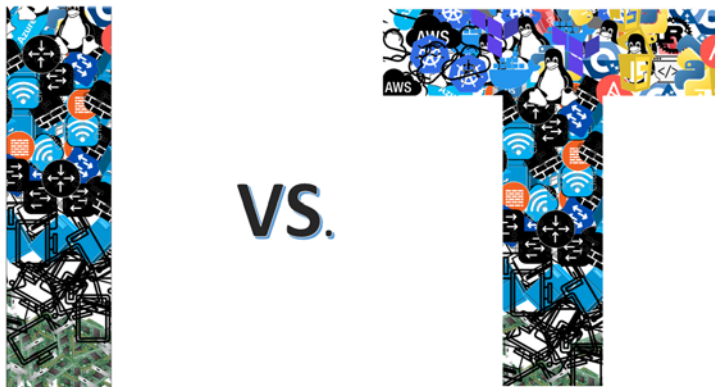


Figure 1-1. *I-shape-minded engineer vs. T-shape-minded engineer*

Throughout this book, you have the opportunity to install, configure, practice, and write Python code on your laptop (or PC) without needing any other expensive and power-hungry enterprise networking equipment. This aspect is crucial for your success in learning Python Network Automation because you can no longer use the lack of equipment as an excuse for not delving into network automation. You only need your laptop and Internet service to get your network automation journey started. If you are following this book and plan to set up your learning environment on a single laptop, doing so will add mobility and flexibility, allowing you to learn anywhere and anytime at your own pace and convenience. To ensure that you have everything you need to get started, I begin by reviewing the minimum system requirements for your setup and introduce you to the full list of software used to complete the tasks outlined in this book. Additionally, I provide guidance on an Integrated Development Environment (IDE) for Python Network Automation development, enhancing your coding experience. You also have access to the download links for all the necessary software, source code, and files used throughout this book, making it easy for you to access the required resources.

By the end of this chapter—whether you’re a network engineer or a student—you will have a better understanding of the current strengths and weaknesses of network engineers compared to software and systems engineers. You will identify any gaps in your knowledge and I will guide you to other areas to expand your horizons, writing Python code, and developing working network automation applications. **Remember, your network automation journey is not a sprint, but rather a series of marathons.** Therefore, it’s essential to build the right foundation to endure the race and remain resilient during setbacks. Keep the long-term goal in mind, and with dedication, you’ll achieve mini successes throughout this book. Let’s embark on this learning journey together and explore the exciting world of Python Network Automation!

Discovering and Developing Your Skills and Prerequisites in the IT industry

This section discusses the skillsets in the three main IT domain groups that are common in the IT industry today. By exploring each group’s strengths and weaknesses, you will gain valuable insights. From the perspective of network engineers, I identify areas where your skills may be lacking and work on developing strategies to strengthen them. While understanding Python syntax and concepts is essential for achieving your network automation goals, based on my own experience, it may only account for 25 percent of

the equation. To write effective Python Network Automation code, you need to develop stronger foundational skills in various areas. In this chapter, I delve into these areas to help you excel. Additionally, I cover Python basics from a networking perspective, and together, we develop a study plan to address the common weaknesses of network engineers. This plan guides you through acquiring the required foundational skills to meet your initial Python Network Automation goals. The aim is to equip you with a well-rounded skillset, enabling you to approach network automation tasks with confidence and expertise.

Python, networks, and automation are each extensive IT topics on their own, and numerous books have been published on each topic. Every year, countless new books about Python, networks, and automation are released, covering a wide spectrum of knowledge. Some books delve into the basics of a topic, while others combine two or more of these areas into a single book. For instance, you can find books that cover purely Python, solely network, exclusively Linux, specifically Python Automation or uniquely Python Network Automation. However, this book takes a unique approach by combining Python, network, and automation into a single comprehensive guide, with a strong focus on understanding practical Linux skills. Linux serves as the foundation of enterprise network automation, making it a crucial component of this book's content.

While many books have attempted to teach readers how to automate enterprise networks using Python, this book takes a unique approach by following the real-world journey of a network engineer learning Python Network Automation from ground zero. As you progress through each chapter, you'll travel along the author's proven path to success while acquiring essential IT skills and gaining insights into writing effective Python code for network automation. This book incorporates the author's working knowledge, study notes, blog content, tips, and tricks used in networking and virtualization solutions to make the learning experience more pleasant and practical at the same time. By drawing from the author's hands-on experience, this book offers a valuable resource that connects theoretical concepts with real-world applications, giving you a deeper understanding of Python Network Automation in a practical context.

Whether you're a student looking to embark on your first Python Network Automation journey or an IT professional working on enterprise-level routing, switching, and security solutions, this book has something to offer. Even if you're a seasoned IT pro with years of experience in enterprise network administration but have yet to explore Python or network automation studies, the contents of this book introduces you to various topics and technologies you may not have encountered before. Furthermore, this

book recognizes that the process of learning and acquiring new skills is just as crucial as achieving study goals and results. The book aims to engage readers whose interests go beyond networking technologies, and who wish to extend their knowledge into Python and Linux. It's not uncommon for IT engineers to feel pressure to be technical experts and know everything, but this book acknowledges the importance of identifying knowledge gaps and helps readers close these gaps for their personal growth and improvement.

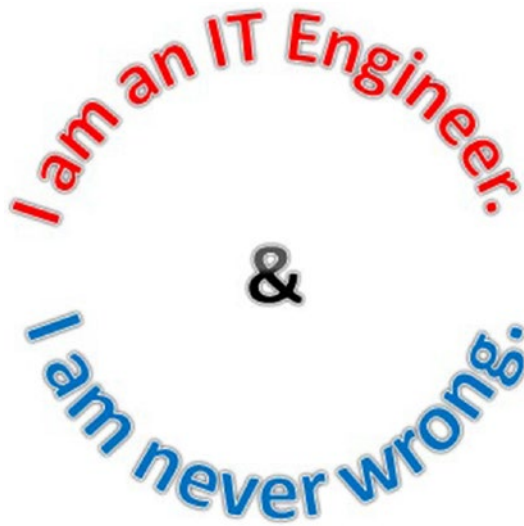


Figure 1-2. *A laughable IT engineer logo*

Figure 1-2 may seem laughable, but it sheds light on the behavior of some IT engineers at work. It serves as a reminder for IT professionals to reflect on their past actions and how they support their customers and enterprise infrastructures. Since the invention of personal computers in 1971, the IT industry has undergone significant changes, resulting in the creation and disappearance of various IT jobs. The constantly evolving enterprise IT ecosystem demands that IT engineers keep up with emerging technologies; those who refuse to do so risk being left behind and possibly losing their jobs. The advent of Artificial Intelligence (AI), the emergence of API-based applications, and newer IT automation tools arrived in the enterprise networking industry a few years back. Those who fail to update their skillset and realign their toolsets may find themselves in an uncertain future in terms of job security. IT professionals need to adapt and embrace these advancements to remain relevant and competitive in the job

market. Staying current with the latest technologies and continuously improving one's skills will not only ensure job stability but will also open doors to exciting new career opportunities. In essence, as long as you're working in the IT field, it's beneficial to stay engaged in self-education activities to remain relevant.

Reflecting on the Past and Observing the Current Trend for a Better Future

For many years, the IT industry has been primarily focused on reducing operational costs by outsourcing less-skilled jobs to developing countries, where IT operational expenses remain comparatively lower than those in advanced countries. In recent times, numerous organizations have made it a priority to cut down on overhead expenses spent on human resources to drive operational costs to a minimum. Unfortunately, in today's business model, human resources are often perceived as overhead costs, while IT customers demand high-quality services while paying less. This situation can lead to financial pressures, forcing drastic IT cost-cutting measures that may compromise the delivery of quality services. Over the last two decades, outsourcing and offshoring efforts have yielded some success, but they have also fueled a relentless drive to further reduce operational costs. This trend has accelerated the adoption of IT automation solutions, such as Software Defined Networking (SDN) and Infrastructure-as-Code (IaC), which have played a pivotal role in lowering costs and enhancing operational efficiency.

Reflecting on the past 23 years and my own experience, the traditional IT operations model saw the vast majority of organizations bearing the cost of running on-premises IT infrastructure and hosting servers in data centers (DCs). However, since the early 2000s, some organizations perceived internal IT operations and support as being overly expensive, leading them to outsource these functions to external IT Managed Services Providers (MSPs). Others, with a presence overseas, chose to relocate their IT operations to countries like India, the Philippines, and Malaysia. While outsourcing IT functions may not always yield perfect results, it undeniably reduces the cost of running IT operations and improves the organization's profit margin. In the field of enterprise networking, new concepts began emerging around 2012, such as network programmability or programmable networks. As early as 2014, network engineers were grappling with the question, "Do I need to become a programmer to stay relevant in networking?" This is my observation, but initially, automation tools like Puppet (2005) and Chef (2009) were introduced primarily for the automation of system devices,

such as Windows or Linux OS, and did not have a significant impact on the uptake of network automation. Python, which had its first version released on February 20, 1991, existed for more than a decade before Ansible emerged in 2012. Ansible, primarily written in Python, became a game-changer as an agentless configuration management tool for automation. Ansible supports both agent and agentless operating systems for automation. Interestingly, since the introduction of Ansible, network engineers have started taking network automation more seriously, and many of them have eagerly embraced this trend, utilizing both Python and Ansible to drive their network automation initiatives.

With the recent migration and widespread adoption of public, private, and hybrid clouds, only a handful of enterprise networking and system devices remain on-premises or within company-owned data centers. In other words, companies have relinquished full control of their platforms in favor of the Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS) models. While we cannot predict the exact future, based on the current trends in the ICT industry, this migration trend is likely to continue, unless a major security breach incident occurs to halt the current trajectory. As we progress further, more and more systems will be driven by software and communicate through Application Programming Interface (API) applications. Consequently, it is not difficult to foresee that engineers will increasingly be expected to deliver services and operational support using APIs or other programming languages, surpassing the traditional Graphical User Interface (GUI) or Command Line Interface (CLI) methods.

Staying Relevant as an IT Professional in a Rapidly Evolving Industry

Do you consider yourself an IT professional? If so, you're likely familiar with the self-reflective question, "What sort of IT professional am I?" As an IT engineer, have you ever asked yourself this question? Or perhaps, "What does my future hold in the ever-evolving IT industry?" If you've chosen IT as your lifelong occupation, chances are you've asked these questions many times throughout your career. Staying competitive in the IT industry is crucial; otherwise, you risk being left behind and forced to move on to the next phase of your career and life. Continually studying and developing your skills in current and relevant IT technologies is no easy task. As someone who was once an upcoming IT engineer, I now find myself becoming an "experienced professional"