Smart Collaborative Identifier Network

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A Promising Design for Future Internet

Springer

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Foreword I

I have known Prof. Zhang and his work for more than 10 years and as a collaborator on a recent project focusing on the future Internet. I am writing to provide my highest recommendation for publishing his proposed book on this subject at your esteemed press.

Professor Zhang is a highly innovative and persevering as well as respected scientist in Chinese academia. He has submerged himself in research on information networks for the past several decades. During that period, he spearheaded many national-level research projects sponsored by National Basic Research Program of China, National High-tech R&D Program and National Natural Science Foundation of China. He has made many significant achievements and inventions and published over 100 papers and several academic writings on this subject. He has also received many awards and recognitions.

It is worth noting that in recent years Prof. Zhang proposed and prototyped a novel future Internet architecture, called the Smart Collaborative Identifier Network, which has many attractive features. The proposed book, Smart Collaborative Identifier Network, is an excellent culmination of his work, which includes Prof. Zhang's latest research findings. There are many new ideas, concepts, and technologies in this proposed book, which will attract the interest of both academia and industry, fostering further advancement of future Internet research.

In short, given the excellence of the author, the topic, and the content, I strongly support the publication of this monograph without any reservation.

Sincerely,
Chunming Qiao
Professor, IEEE Fellow
Department of Computer Science and Engineering
University at Buffalo, SUNY, Buffalo, NY, USA

Foreword II

Prof. Hongke Zhang requested a letter of recommendation from me to support publishing his new monograph at your world-renowned press. As his acquaintance, I am pleased to comply with his request.

Prof. Hongke Zhang has applied himself to research on the communication network for many years. He has written numerous famous academic writings, including Principle and Technology of IPv6 Routing Protocol Stack, Mobile Internet Technology, Principle and Technology of Routers and so on. All of his research findings have been widely accepted. In recent years, he has received strong state patronages for several national-level projects from the National Basic Research Program of China ("973 Program"), National High-tech R&D Program ("863 Program") and National Natural Science Foundation of China. Certainly, he has obtained a series of significant academic achievements as well.

What distinguished him among his colleagues, I think, is his recent accomplishments in future Internet architecture, the Smart Collaborative Identifier Network, which theoretically solves the existing problems of the current Internet. Moreover, the feasibility and reliability of this novel Internet architecture has been demonstrated by the telecom industry. To spread these valuable ideas, Prof. Hongke Zhang has spent a lot of time and effort on writing this monograph. As far as I know, this book is the first one focusing on the future Internet architecture, mechanisms, and technologies. This book makes a detailed elaboration of the working principles, key technologies and prototype system of the Smart Collaborative Identifier Network. It also makes great contributions to promoting the development of the future Internet.

In summary, I have every reason to believe that this book will be an outstanding performance. I would greatly appreciate it if you give this book favorable consideration. Please feel free to contact me directly if more assistance is needed.

Sincerely yours,
Dr. Sy-Yen Kuo, IEEE Fellow
Distinguished Professor, Department of Electrical Engineering
National Taiwan University

Foreword III

I am very glad to write this reference letter in support of the publication of this monograph.

In recent years, the research on the future Internet architecture and mechanisms has become a most important topic in the area of the information network. As far as I know, there are many different proposals for the future Internet all over the world, such as CCN/NDN, DONA, PSIRP and so on. However, few monographs detailing the future Internet design can be found so far. This book, Smart Collaborative Identifier Network—A Promising Design of Future Internet, is the first great monograph especially about the future Internet. It introduces the clean-slate network architecture clearly, including the basic theories and advanced technologies. The Smart Collaborative Identifier Network has great potential to overcome the drawbacks of the current Internet and satisfy emerging demands of the future Internet.

The authors, Prof. Hongke Zhang and his team, have been devoted to the research on the future Internet for decades. Prof. Zhang has rich experience in the area of the future Internet. During the past decades, he has been the chief scientist for numerous national research projects, such as the "Basic Research on Theories of Smart and Cooperative Networks" founded by the National Basic Research Program of China ("973 Program"). He has also published several academic works concentrating on the technologies of the computer network, such as the Principle and Technology of Routers, Mobile Internet Technology, Principle and Technology of the Ipv6 Routing Protocol Stack and so on. This book is another great achievement of his recent research.

In a word, this book proposes a many new ideas, new concepts, and new technologies of the future Internet. In my opinion, this book has an important academic value and is also very significant for the deployment of the future Internet. I also hope that this book will make great contributions to the development of the future Internet.

Yours honestly,
Zhou Bingkun
Academician, Chinese Academy of Sciences
Tsinghua University, Beijing, China

Preface

Over the past few decades, the Internet, as a huge success, has permeated almost every aspect of our daily life. However, with its fast growth and development, the current settings of the Internet exhibit various shortcomings, for instance, the security problems, the lack of support of flexible services, the inability to provide mobility and the insufficient support of manageability. These shortcomings are serious obstacles to the further development of the Internet. Therefore, the networking research community has engaged in an ongoing conversation about how to move the Internet forward.

Arguments about whether researchers should focus on improving today's Internet architecture or on designing new network architectures, which are unconstrained by the current system, always exist. Jennifer Rexford from Princeton University first gave his viewpoint that a "clean-slate design is important for enabling the networking field to mature into a true discipline, and to have a future Internet that is worthy of society's trust." We believe this could be proven eventually. Furthermore, although there have been many improvements on top of the current Internet architecture, few, if any, can comprehensively, effectively and sustainably solve the aforementioned problems.

More and more researchers have recently reported that problems about the Internet originate mostly from the limitations of its primary design. Many efforts have been made worldwide to investigate and develop the future Internet technologies and systems. Furthermore, the research community and the telecom industry have started to explore the new approaches to build the future Internet, such as Future Internet Network Design (FIND), Future Internet Architecture (FIA) in the USA; Future Internet Research and Experimentation (FIRE) and FIRE + in the European Union. Now, designing and building up the future Internet frame has become one of the most important and urgent topics in the research field of information networks. Thanks to these efforts, remarkable progress has been made for the future Internet. However, a general and ultimate solution for the future Internet has yet to be introduced.

This book examines the recent research on the future Internet all over the world and introduces a promising design for the future Internet named by *Smart*

Collaborative Identifier Network (SINET). SINET is intended to address the main issues and defects existing in the current Internet architecture. In this book, we present SINET's basic theories and principles, a broad range of architectures, protocols, standards and future research directions. Over the last decade, a variety of theoretical models and industrial applications have demonstrated that SINET is able to manage most of the problems of today's Internet. Through the comprehensive experiments and practical verification, SINET offers impressive flexibility, security, mobility, manageability and efficient resource utilization.

The book consists of 13 chapters in total. To give a clear and all-round introduction to the SINET, the chapters are further categorized into three parts. First, we introduce the Theory and Principle of SINET in Part I, which includes Chaps. 1–6. With knowledge of the basic principle, we detail many key technologies of SINET in Part II, which consists of Chaps. 7–10. Finally, some applications and developments are discussed and analyzed in Part III, comprising Chaps. 11–13.

To profit the audience the most, we expect the readers to have basic knowledge of the current Internet architecture and a brief understanding of how the current Internet works. This book can be used as a reference for researchers and practitioners interested in or working in the field of Internet design and the future Internet architecture. The contents are also suitable for both graduate students and senior undergraduate students in the fields of computer science, information science, computer networks and communication engineering. We hope that this book will serve as a valuable blueprint and contribute to the future Internet. We also hope to attract more researchers worldwide in this community to exchange ideas and to build a more effective and powerful Internet collaboratively.

Beijing, China

Hongke Zhang
Wei Su
Wei Quan

Acknowledgements

Many researchers have assisted me technically in writing this book. I am very grateful. Without their help, the book might never have been finished. My deepest thanks go to Prof. Chunming Qiao (University at Buffalo, The State University of New York), Prof. Sy-Yen Kuo (National Taiwan University), Prof. Bingkun Zhou (Chinese Academy of Sciences), Prof. Youzhi Xu (Mid Sweden University) and Gidlund Mikael (ABB, Sweden), who were so kind as to fully support us in writing this book and give us many valuable suggestions. They are all experts in their respective fields.

I am also very grateful to Prof. Wei Su, Dr. Wei Quan and Dr. Jia Chen, who are all outstanding researchers in our team and helped greatly in the organization of the whole contents of this book (each of them contributed at least four chapters, Chaps. 1–4, Chaps. 5–8, Chaps. 9–13, respectively). Many other researchers have also assisted in various ways during the preparation of this book. I am thankful to Huachun Zhou, Deyun Gao, Yajuan Qin, Hongbin Luo, Changqiao Xu, Fei Song, Dong Yang, Ping Dong, Ying Liu, Hongchao Wang, Shuai Gao, Tao Zheng and Jianfeng Guan. They have shared many research ideas over the years, which are mostly included in this book, and/or also been a great help in pointing out errors in the texts, examples and algorithms.

My current students, Zhongbai Jiang, Ying Rao, Ru Jia, Fei Ren, Yakun Xu, Xiaojun Xie, Bosong Liu, Bingjie Han, Tongming Zhang, Chunqiu Shi, Yana Liu, Yun Zhao, Wei Huang and Peipei Jing, contributed as well by researching/preparing materials for several chapters and/or checking chapters and made numerous corrections. This book also refers to the works of several of my former students. To list them all would be impossible, but I would particularly like to thank Huaming Guo, Feng Qiu, Xiaoqian Li, Shuigen Yang, Ming Wan and Jianqiang Tang.

It was a pleasure working with the helpful staff at Springer. I thank my editor Dr. Celine Chang, Dr. XiaoLan Yao and Miss. Jane Li, who gave us great guidance in preparing this book, helped us improve the presentation, and guided us through the final production process. Working with them has been a wonderful experience.

Three anonymous book reviewers selected by Springer also gave us many insightful comments.

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Last but not least, my greatest gratitude goes to my family. They have helped me in so many ways unconditionally, in particular my wife, who has taken care of everything at home and put up with me during the long hours that I have spent on this book. I dedicate this book to them.

November 2015 Hongke Zhang

Contents

Acronyms

AC	Authentication Center
ACK	ACKnowledge
ACN	ACcess Network
ADNT	Anomaly Detection based on Network Traffic
ADRM	Anomaly Detection Response Mechanism
AID	Access IDentifier
AID-RM	AID Resolution Mapping
ALT	Alternative Topology
ARPA	Advanced Research Projects Agency
ARPANET	Advanced Research Project Agency Network
ASR	Access Switching Router
BGP	Border Gateway Protocol
CCN	Content-Centric Networking
CERNET	China Education and Research Network
CID	Connection IDentifier
CID-RM	CID Resolution Mapping
CoA	Care of Address
CON	COre Network
CPS	Content Providing Server
CUSUM	Cumulative Sum
DDoS	Distributed Denial of Service
DHT	Distributed Hash Table
DONA	Data Oriented Network
DoS	Denial of Service
EU	European Union
FBD	Family Behavior Description
FIA	Future Internet Architecture
FID	Family IDentifier
FIND	Future Internet Design
FIRE	Future Internet Research and Experimentation

FP7	EU's Seventh Framework Program (FP7)
GSR	General Switching Router
HA	Home Agent
HIP	Host Identity Protocol
HTTP	Hyper Text Transfer Protocol
ICCC	Intelligent Central Control Component
ICT	Information Communication Technologies
IDMS	Identifier Mapping Server
IETF	Internet Engineering Task Force
IP	Internet Protocol
IRTF	Internet Research Task Force
ISP	Internet Service Provider
ISRS	Intelligent Service Resolution Server
KM	Kermack-Mckendrick
LISP	Locator/Identifier Separation Protocol
MIP	Mobile IP
MIPv6	Mobile IPv6
MN	Mobile Node
MOST	Ministry of Science and Technology
MR	Mobile Router
MTC	Mobile Terminal Component
NAT	Network Address Translation
NBD	Node Behavior Description
NDN	Named Data Networking
Net-Inf	Network of Information
NGIT	National Engineering Laboratory for Next Generation Internet Technologies
NID	Node IDentifier
NRS	Name Resolution Server
NSC	Network Switching Component
NSF	National Science Foundation
NSFC	National Natural Science Foundation of China
NSFNET	National Science Foundation Network
NSR	Network Switching Router
PIT	Pending Interest Table
PN	Provider Network
P2P	Peer-to-peer
QoS	Qualtiy of Service
RARS	Resource Adapting Resolution Server
RH	Resolution Handler
RID	Routing Identifier
RM	Resolution Mapping
RP	Rendezvous Point
RTT	Round-Trip Time
SAP	Service Access Point

SB	Service Binding
SBD	Service Behavior Description
SCTP	Transmission Control Protocol
SDN	Software Defined Network
SID	Service Identifier
SID-RM	SID Resolution Mapping
SINET	Smart Identifier NETwork
SIP	Session Initiation Protocol
SIR	Susceptible-Infectious-Removed
SIS	Susceptible-Infectious-Susceptible
SMS	Service Management System
STC	Stable Terminal Component
SYN	SYNchronous
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
URL	Uniform Resource Locator
VAM	Virtual Access Module
VBM	Virtual Backbone Module
VCM	Virtual Connection Module
VSM	Virtual Service Module
XIA	eXpressive Internet Architecture

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