Daniel Minoli • Jo-Anne Dressendofer

High-Density and De-Densified Smart Campus Communications

Technologies, Integration, Implementation, and Applications

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HIGH-DENSITY AND DE-DENSIFIED SMART CAMPUS COMMUNICATIONS

Technologies, Integration, Implementation, and Applications

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In loving memory of my wife Anna (Dan)

> *Era una santa e completò la sua missione con passione, pur giovane.*
>
> *“E se dal caro oggetto, Lungi convien che sia, convien che sia, Sospirerò penando, Ogni momento”* (from a stanza in Vivaldi's “Vedrò con mio diletto”)

In loving memory of my mother Helene (Jo-Anne)

> *Who was there for every tear along my not-so-easy career and pushed me to dream even bigger*

PREFACE

High-density campus communications have traditionally been important in many environments, including airports, stadiums, convention centers, shopping malls, classrooms, hospitals, cruise ships, train and subway stations, evangelical megachurches, large multiple dwelling units, boardwalks, (special events in) parks, dense smart cities, and other venues. These communications span several domains: people-to-people, people-to-websites, people-to-applications, sensors-to-cloud analytics, and machines-to-machines/device-to-device. While the later Internet of Things (IoT) applications are generally (but not always) low speed, the former applications are typically high speed. In many settings, people access videos (*a la* Over The Top [OTT] mode) or websites and applications that often include short videos or other high data-rate content. Deploying optimally performing high-density campus communication systems is desired and required in many cases, but it can, at the same time, be a complex task to undertake successfully.

High-density campus communications play a role in the evolution of Smart Campuses but also drive the Smart City and Smart Building use cases. Connectivity is now considered a fourth utility (in addition to gas, water, and electricity). In fact, massive-type communication is a recognized requirement of 5G, even if just in the machine-type communication environment. In the campus applications just cited, people-to-people, people-to-websites, and people-to-applications connectivity is increasingly important, given that nearly everyone now carries a smartphone and many apps entail high-throughput transmissions.

There are unique requirements and unique designs required for high-density communications, particularly because of the relative scarcity of available spectrum. In addition, there has been and continues to be a set of transitions, even transformations, of the underlying technologies. The world has moved to IP for all data, voice, and video communications. Additionally, there is a trend toward the use of Wi-Fi-based hotspot communication in all practical situations, due to near ubiquity of service, lower end-user costs, higher bandwidth, technical simplicity, lower infrastructure costs, decentralized administration, regulation relief, and non-bureaucratic delivery of service (without the reliance of large institutional providers). While 5G promises to deliver a set of new capabilities, neither 3G nor 4G displaced Wi-Fi as a common access technology in the office, in the campus, on the street, and in travel. The technologies per se used for high-density communications are not new (perhaps with the exception of 5G), but the requirements, as well as the design and system synthesis, are relatively unique.

As the second decade of the twenty-first century rolled along, however, a new requirement presented itself due to the worldwide pandemic: physical/desk distancing in support of Office Social Distancing (OSD) and Office Dynamic Cluster Monitoring and Analysis (ODCMA). Wireless technologies have been harvested to address and manage these pressing issues. Real-Time Locating Systems (RTLS) have been employed for a number of years to automatically identify and then track the location of objects or people in real-time, within a building, or in other constrained locations are seeing renewed interest and applications. Even if effective vaccines are found and distributed globally, the common opinion is that many (but not all) societal and workplace changes driven by the pandemic may become permanent.

This book assesses the requirements, technologies, designs, solutions, and trends associated with High-Density Communications (HDC). We believe this to be the first book that specifically synthesizes the topic of applied high-density communications. Chapter 1 looks at the functional requirements for high-density communications. Chapter 2 discusses the traditional data/Wi-Fi Internet access, including OTT video. Chapter 3 addresses the traditional voice/cellular design for campus applications, especially the Distributed Antenna System (DAS). Chapter 4 peruses the traditional sensor networks/IoT services approaches. Chapter 5 is the core of this text and examines evolved Wi-Fi hotspot connectivity and related technologies (Wi-Fi 5, Wi-Fi 6, spectrum, IoT, VoWiFi, DASs, microcells issues, 5G versus Wi-Fi issues), as well as intelligent integration of the discrete set of campus/venue networks into a cohesive platform usable in airports, stadiums, convention centers, classrooms, hospitals, and the like.

Chapter 6 starts the discussion on de-densification, using the same kind of technologies discussed in part one of the book; it considers the topic of office social distancing and discusses one of the available technologies. Chapter 7 covers the use of Ultra-Wideband (UWB) technologies. Chapter 8 addresses the office social distancing challenge using Wi-Fi, Bluetooth, and cellular/smartphone methodologies. Chapter 9 provides a use case for HDC systems, and Chapter 10 offers a pragmatic view for some of the economics of broad deployment of HDC.

The book is targeted to networking professionals, technology planners, campus administrators, service providers, equipment vendors, and educators. It is not a research monograph, but rather it aims at integrating the real-world deployment of technologies, strategies, and implementation issues related to delivering an actual working HDC environment in any of the key venues listed

above. It is important to note that the composition of this book started in February 2020. While social distancing in the office and public venues was a crucial short-term goal at press time, the business- and public-venue density requirements will likely resurge over time, likely with some yet to be foreseen modifications.

Many books delve extensively on general technologies of all types; however, they fall short in terms of the economics of such technologies, deployment challenges, associated security issues, and most lack tangible case studies. This book addresses these key aspects, based on actual deployment by the team associated with this writing, at a top US airport.

Some portions of this text make use of patent material filed with the United States Patent Office. All inventors cited are implicitly acknowledged for their contribution to this synthesis.

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30 December 2020

ABOUT THE AUTHORS

DANIEL MINOLI

Mr. Minoli is the principal consultant at DVI Communications. He has published 60 technical telecom and IT books, many are the first in their field (e.g., the first-ever book on VoIP, the first-ever on outsourcing of telecom services, the first-ever book on metro Ethernet, the first-ever book on green networks, the first-ever book on IPv6 security, the first book on public hotspots, and the first book on IPv6 support of IoT, among others); he has also published 340 other papers (the majority of which are peer-reviewed). Many books focus on raw technologies and fail to address Return on Investment (ROI), deployment, security considerations, and to provide case studies; Mr. Minoli's books aim to address these key issues when documenting the applicability of the underlying technologies.

Mr. Minoli started to work on wireless LANs in the late 1970s as part of ARPANet-sponsored R&D and continued wireless work in the form of Geo/Meo satellite transmission, microwave, free space optics, mmWaves/“wireless fiber,” cellular, Wi-Fi WLANs, sensor networks, wireless IoT, crowdsensing, 900 MHz SCADA, BMSs, UltraWideband, and 5G. He has written two books on LANs and several long book chapters on WLANs in other books; and, as noted, he has written a book on public hotspots and a book on metroEthernet/VPLS. At press time, over 225 published US patents, as well as 38 US patent applications, cite his work. Additionally, 5917 academic researchers cite his work in their own publications, according to Google Scholar, including 1887 citations of his books on Wireless Sensor Networks, 569 of his

books/papers on IoT, 344 of his books on enterprise architectures, 262 of his books on video, and 259 of his books on VoIP. Mr. Minoli is a reviewer for several publishers, including Elsevier, Springer, IEEE, and Wiley. He has taught (adjunct) over 75 college graduate/undergraduate courses at New York University, Stevens Institute of Technology, and Rutgers University. He has been affiliated with Nokia, Ericsson, AT&T, SES, Prudential Securities, Capital One Financial, and AIG, and has been an expert witness/testifying expert in about 20 patent lawsuits. He has undertaken Intellectual Property (IP) work related to patent invalidity, infringement/non-infringement analysis, breach-of-contract, dispute of equipment functionality, and IP portfolio valuation in the area of packet video/IPTV, packet voice/VoIP, networking, imaging (scanned checks), IoT, and wireless. He has provided Court testimony, sustained numerous depositions, and produced numerous Expert Reports, Rebuttal Reports, and Post Grant Review Declarations.

JO-ANNE DRESSENDOFER

Jo-Anne (Josie) Dressendofer is the founder of SliceWiFi. The firm was launched in 2016 to address the rapidly expanding need for fast, reliable Wi-Fi service in permanent and temporary locations. What started as a goal to become the first “Managed Wi-Fi Brand” ended up becoming the first company to compete with the goliath cellular companies, with Wi-Fi and an all-inclusive technology, turning SliceWiFi into a telecommunications company overnight. SliceWiFi initially achieved market recognition in New York City, as one of the leading Wi-Fi providers in the NY metro area, after successfully supporting difficult, densely populated networking environments such as the Javits Center and downtown Brooklyn rebuilding after Hurricane Sandy; NY Fashion Week's many simultaneous event locations; many

hackathons with over a thousand users; the Staten Island Ferry during peak travel over the Hudson River; and the parks at Hudson Yards where no fiber was to be had. In 2017, SliceWiFi won *CIO* magazine's category award for “Top Wireless Solution Providers.”

Ms. Dressendofer has led a 25-year career in the tech industry, competing aggressively and winning repeatedly against larger, better-financed multi-billion-dollar competitors. Her firms have a record of being more creative with leading-edge technology deployment and networking engineering than all the legacy providers in play. The recent win at BWI Thurgood Marshall Airport (BWI) against major players in the telecommunications industry was transcendent and proof that the SuperNetwork concept (Chapters 9 and 10) is not only a trendsetter but a victory for all women in technology.

ACKNOWLEDGMENTS

In addition to the inventors cited in this work, Mr. Minoli wishes to warmly thank Mr. Benedict Occhiogrosso, President, DVI Communications, for the continued support and input in all the bleeding-edge technologies discussed in this text. DVI Communications, Inc. is a leading and highly respected Information Technology, ICT consultancy, and systems engineering firm with core competencies in IT, ICT, IoT, M2M, wireless, telecom, security, and audiovisual systems. Throughout its 40+ year history, the firm has supported many organizations deploying traditional and emerging technologies, serving both large enterprises and smaller organizations in numerous vertical markets with complex, state-of-the-art systems often working alongside legacy systems, supporting several generations of technology simultaneously.

Ms. Dressendofer wishes to credit and thank the staff of Slice Wireless Solutions, Inc. (SliceWiFi) for the support of this initiative, as described in Chapter 9 and further synthesized in Chapter 10, in the context of designing and deploying a reimagined Thurgood Marshall Airport (BWI) SuperNetwork and the development of WiSNET. The complete redesign and the initial redeployment of the entire BWI Airport terminal-side and some portions of the operations wireless communication infrastructure, amid the COVID-19 pandemic and the span of 12 months, all while maintaining reliable, uninterrupted airport service, was an enormously complex task. Much has been learned at the practical level and is documented in the last two chapters of this book. John Hutzler, COO, and Ed Wright, CTO, have been instrumental in the successful design and completion of this SuperNetwork redeployment mission, even more so