

controller area network for dummies

Controller Area Network for Dummies: Understanding the Basics of CAN Bus Technology

controller area network for dummies is a phrase that perfectly captures the need for a simple, straightforward explanation of one of the most important communication protocols used in automotive and industrial applications today. If you've ever wondered how various electronic components in cars, trucks, or even factory machines talk to each other without a tangle of wires, the answer lies in the Controller Area Network, commonly known as CAN bus. This article will walk you through the fundamentals of CAN, making it easy to understand even if you're new to electronics or automotive technology.

What is a Controller Area Network?

At its core, a Controller Area Network (CAN) is a robust vehicle bus standard designed to allow microcontrollers and devices to communicate with each other without a host computer. Developed by Bosch in the 1980s, CAN was initially created to reduce wiring complexity in automobiles, making communication between Electronic Control Units (ECUs) efficient and reliable.

Unlike traditional point-to-point wiring systems where every device needs a dedicated connection, CAN allows multiple devices to share the same communication bus. This means fewer wires, less weight, and easier diagnostics — all vital in modern vehicles and machinery.

Why is CAN Important?

CAN has become the backbone of in-vehicle networking because it simplifies the communication process. Modern cars can have tens, sometimes hundreds, of ECUs controlling everything from engine timing to airbags and infotainment systems. Without CAN, managing this web of communication would be a nightmare.

Moreover, CAN's error detection and fault confinement mechanisms make it highly reliable, ensuring that messages are correctly delivered even in electrically noisy environments like automobiles.

How Does a Controller Area Network Work?

Understanding the working principle of CAN can seem daunting at first, but it's quite logical once broken down.

The Basics of CAN Communication

CAN uses a two-wire twisted pair cable, known as CAN High (CAN_H) and CAN Low (CAN_L), to

transfer data. These wires transmit differential signals, which helps reduce electromagnetic interference — an essential feature in the noisy environment of a vehicle.

Each device connected to the CAN bus is called a node. Every node can send and receive messages, but the messages themselves don't have specific addresses. Instead, messages are identified by unique identifiers (IDs) which also determine their priority on the bus.

Message Arbitration and Prioritization

One of the clever aspects of CAN is how it handles message collisions. Since multiple nodes might want to send messages simultaneously, CAN uses a method called arbitration. The message with the highest priority (lowest ID number) wins the bus and gets transmitted first, while others wait. This prevents data loss and ensures that critical information like engine or safety sensor data is prioritized.

Data Frames and Error Handling

A CAN message consists of several parts: an identifier, control bits, data field (up to 8 bytes), and error checking bits. The protocol includes built-in error detection methods such as Cyclic Redundancy Check (CRC), acknowledgment checks, and bit monitoring, making CAN exceptionally reliable.

If errors are detected, nodes can automatically retransmit the message. Additionally, faulty nodes can be temporarily or permanently removed from the bus to prevent data corruption.

Common Applications of Controller Area Network

While CAN is most famous for its role in automotive systems, its usefulness extends beyond just cars.

Automotive Systems

In vehicles, CAN links together critical components such as the engine control module, transmission, antilock braking systems, airbags, power windows, and even climate control. This integration allows real-time monitoring and control, improving safety, performance, and efficiency.

Industrial Automation

Manufacturing plants and industrial machines often use CAN networks to coordinate sensors, actuators, and controllers. The protocol's reliability and robustness in electrically noisy environments make it ideal for factory floors.

Medical Equipment and Aerospace

CAN is also found in medical devices where precise communication is crucial and in aerospace for system monitoring and control, underscoring its versatility.

Controller Area Network for Dummies: Key Terms to Know

To make sense of CAN, it helps to familiarize yourself with some common terms:

- **Node:** Any device connected to the CAN bus.
- **Bus:** The physical medium (wires) over which data is transmitted.
- **ID (Identifier):** A unique number that identifies the message and its priority.
- **Data Frame:** The structure of a CAN message containing control and data bits.
- **Arbitration:** The process of deciding which node gets to transmit when multiple nodes try simultaneously.
- **Bit Stuffing:** A technique to maintain synchronization by inserting non-informational bits.
- **CRC (Cyclic Redundancy Check):** An error-checking mechanism.

Understanding these terms can make reading CAN documentation or troubleshooting easier for beginners.

Tips for Beginners Learning Controller Area Network

If you're new to CAN and want to dive deeper, here are some helpful tips:

Start With Simple Projects

Begin by experimenting with basic microcontroller kits that support CAN communication, like Arduino with CAN shields or Raspberry Pi with CAN adapters. Simple projects such as sending and receiving messages between two nodes will build your confidence.

Use Simulation Tools

Several software tools allow you to simulate CAN networks without hardware. These can help you understand message flow, arbitration, and error handling before moving to physical setups.

Explore Diagnostic Tools

Professional CAN analyzers and software can capture and decode CAN traffic. Even entry-level tools can offer insights into message IDs and data, which is invaluable for learning and troubleshooting.

Understand the Protocol Layers

CAN is defined in the ISO 11898 standard, which includes physical and data link layers. While beginners don't need to memorize the entire standard, understanding the difference between the physical bus (wires and voltage levels) and logical communication (messages and protocols) helps clarify the bigger picture.

Common Challenges and How to Overcome Them

Even though CAN is designed for robustness, beginners often face some common hurdles.

Wiring and Termination

Proper wiring is essential. CAN bus requires a twisted pair cable with a 120-ohm termination resistor at each end of the bus to prevent signal reflections. Missing or incorrect termination can cause communication errors.

Message Identification Conflicts

Since message IDs determine priority, duplicate IDs can cause conflicts. When adding new nodes, ensure unique identifiers are assigned to avoid collisions.

Dealing with Noise

CAN is resilient against noise, but extreme electromagnetic interference (EMI) can still cause issues. Using shielded cables and proper grounding helps maintain signal integrity.

The Future of Controller Area Network

While traditional CAN remains widely used, advancements like CAN FD (Flexible Data-rate) offer higher data rates and larger payloads, making CAN suitable for even more complex applications. Additionally, CAN is increasingly integrated with automotive Ethernet and other protocols to meet the demands of connected and autonomous vehicles.

For anyone stepping into automotive electronics, industrial automation, or embedded systems, understanding the controller area network is a foundational skill that opens up numerous possibilities.

Whether you're a student, hobbyist, or professional, mastering CAN communication will give you greater insight into how modern electronic systems work seamlessly together — a true marvel of engineering hidden beneath the hood and behind the control panels.

Frequently Asked Questions

What is a Controller Area Network (CAN)?

A Controller Area Network (CAN) is a robust vehicle bus standard designed to allow microcontrollers and devices to communicate with each other without a host computer. It is commonly used in automotive and industrial applications.

How does CAN communication work?

CAN communication works by sending messages called frames over a two-wire bus. Each node on the network can transmit and receive messages, and messages are prioritized by unique identifiers to avoid collisions.

What are the main components of a CAN system?

The main components of a CAN system include the CAN controller, CAN transceiver, and the physical bus (twisted pair wires). The controller manages the message protocol, the transceiver handles signal conversion, and the bus connects all nodes.

Why is CAN important in automotive systems?

CAN is important in automotive systems because it allows various electronic control units (ECUs) like engine control, airbags, and antilock brakes to communicate efficiently and reliably, reducing wiring complexity and improving diagnostics.

What are the basic types of CAN frames?

The basic types of CAN frames include data frames (which carry data), remote frames (request data), error frames (indicate errors), and overload frames (provide extra delay). Data frames are the most commonly used.

What is the difference between CAN 2.0A and CAN 2.0B?

CAN 2.0A supports standard frames with an 11-bit identifier, while CAN 2.0B supports extended frames with a 29-bit identifier, allowing for more devices and message types on the network.

What tools do beginners need to start working with CAN?

Beginners typically need a CAN interface device (such as a USB-to-CAN adapter), a computer with CAN analysis software, and basic knowledge of CAN protocols to start experimenting and learning.

How can errors be detected and handled in a CAN network?

CAN networks use built-in error detection mechanisms including cyclic redundancy check (CRC), bit stuffing, acknowledgment, and error counters. When errors are detected, the network automatically retransmits frames or isolates faulty nodes to maintain communication.

Additional Resources

Controller Area Network for Dummies: An In-Depth Exploration of CAN Technology

controller area network for dummies is a topic that demystifies one of the most critical communication protocols used in modern electronics, especially in automotive and industrial applications. As vehicles and machines become increasingly complex, the need for efficient and reliable data exchange between microcontrollers and devices has never been greater. The Controller Area Network (CAN) emerges as a robust solution, enabling multiple electronic control units (ECUs) to communicate without a host computer. This article unpacks the fundamental concepts of CAN, targeting readers who seek a clear, professional understanding without prior technical expertise.

Understanding the Basics of Controller Area Network

The Controller Area Network is a serial communication protocol originally developed by Bosch in the 1980s to address the burgeoning complexity of automotive electronics. Unlike traditional point-to-point wiring systems, CAN connects multiple control nodes on a single communication bus, allowing them to send and receive messages efficiently. The protocol reduces wiring complexity, weight, and cost, while enhancing reliability and fault tolerance.

At its core, CAN operates on a message-oriented communication scheme, where data frames are broadcast across the network. Each node can receive all messages but only processes those relevant to its function based on message identifiers. This prioritization mechanism ensures critical messages gain immediate bus access, making CAN particularly suitable for time-sensitive and safety-critical applications.

The Architecture and Protocol Layers of CAN

To grasp controller area network for dummies, it's essential to understand the layered structure of

CAN communication. CAN follows the OSI model partially, primarily encompassing the data link and physical layers.

- **Physical Layer:** Defines the electrical and mechanical specifications, including voltage levels, bit timing, and cabling. Commonly, twisted-pair cables are used to minimize electromagnetic interference.
- **Data Link Layer:** Handles message framing, error detection, arbitration, and acknowledgment. This layer ensures data integrity and prioritizes message transmission based on identifiers.

Higher-level protocols often operate on top of CAN to manage application-specific requirements, such as CANopen or DeviceNet, but the fundamental controller area network protocol focuses on efficient node-to-node communication.

Why Controller Area Network Matters in Modern Systems

The versatility and robustness of CAN have made it a standard in automotive electronics, industrial automation, and increasingly in medical and aerospace sectors. For those delving into controller area network for dummies, understanding its real-world impact is crucial.

Automotive Applications

Modern vehicles contain dozens of ECUs managing everything from engine control and braking to infotainment systems. CAN enables these ECUs to share sensor data and commands seamlessly, improving performance and safety.

- **Reduced Wiring Complexity:** Instead of individual wires connecting each ECU, a single CAN bus links them all, reducing weight and potential failure points.
- **Real-Time Communication:** CAN's arbitration scheme ensures that critical messages, such as airbag deployment signals, are transmitted instantly.
- **Fault Tolerance:** Built-in error detection and retransmission mechanisms improve reliability in harsh automotive environments.

Industrial and Embedded Systems

Beyond vehicles, CAN networks facilitate communication in manufacturing equipment, robotics, and

embedded systems. Their resilience to electrical noise and support for multi-master configurations make them ideal for factory automation.

Key Features and Advantages of CAN

Exploring controller area network for dummies further reveals several technical features that differentiate CAN from other communication protocols such as LIN (Local Interconnect Network) or FlexRay.

Message Prioritization and Arbitration

CAN uses a non-destructive bitwise arbitration method based on message identifiers. When multiple nodes attempt transmission simultaneously, the message with the highest priority (lowest identifier number) gains bus access without data loss or collision.

Error Detection and Handling

CAN implements multiple error detection mechanisms:

- **Cyclic Redundancy Check (CRC):** Ensures data integrity.
- **Bit Monitoring:** Detects bit errors during transmission.
- **Form and Stuff Errors:** Checks frame structure and bit stuffing rules.
- **Error Counters:** Track node health and can isolate faulty devices.

These features contribute to CAN's reputation as a highly reliable communication protocol.

Data Rate and Frame Types

Standard CAN supports data rates up to 1 Mbps, sufficient for most automotive and industrial tasks. For applications demanding higher speeds, CAN FD (Flexible Data-rate) extends throughput up to 8 Mbps and allows larger data payloads per frame.

Frames in CAN include:

- **Data Frames:** Carry actual information.

- **Remote Frames:** Request data from other nodes.
- **Error Frames:** Indicate transmission errors.
- **Overload Frames:** Provide extra delay between frames.

Comparing CAN with Other Communication Protocols

For those new to controller area network for dummies, it's insightful to contrast CAN with alternative communication standards.

CAN vs. LIN

LIN is a simpler, low-cost protocol designed for non-critical applications like window controls or seat adjustments. Unlike CAN's multi-master bus, LIN uses a single master with multiple slaves and supports lower data rates (up to 20 Kbps). CAN's robust error handling and higher speed make it preferable for safety-related systems.

CAN vs. FlexRay

FlexRay offers higher data rates (up to 10 Mbps) and deterministic communication, suitable for advanced driver-assistance systems (ADAS). However, it is costlier and more complex. CAN remains dominant for less demanding applications due to its balance of cost, reliability, and speed.

Challenges and Limitations of Controller Area Network

While controller area network for dummies introduces a powerful technology, it's important to acknowledge its constraints.

- **Limited Bandwidth:** Standard CAN's maximum 1 Mbps may be insufficient for data-intensive systems like video streaming or radar sensors.
- **Scalability:** Large networks may suffer from latency and bus loading issues.
- **Security Concerns:** CAN lacks inherent encryption or authentication, making it vulnerable to cyberattacks without additional safeguards.

Addressing these challenges often involves integrating higher-layer security protocols or adopting

complementary communication technologies.

Getting Started with Controller Area Network

For engineers and enthusiasts keen on exploring CAN networks, several tools and resources facilitate learning and implementation.

- **Development Kits:** Affordable microcontroller boards with built-in CAN controllers (e.g., Arduino with CAN shields, Raspberry Pi with CAN HATs).
- **Software Tools:** CAN analyzers and simulation software enable monitoring and debugging of bus traffic.
- **Standards Documentation:** Reviewing ISO 11898 and Bosch specifications provides in-depth protocol understanding.

Hands-on experimentation combined with theoretical study is an effective strategy to master controller area network concepts.

In sum, the controller area network for dummies guide illuminates a critical cornerstone of modern embedded communication. Its blend of simplicity, reliability, and efficiency sustains its widespread adoption across various industries, shaping the way electronic systems interact in our increasingly connected world.

Controller Area Network For Dummies

controller area network for dummies: A Comprehensible Guide to Controller Area Network Wilfried Voss, 2008 Controller Area Network (CAN) is a serial network technology that was originally designed for the automotive industry, but has also become a popular bus in industrial automation. The CAN bus is primarily used in embedded solutions and provides communication among microprocessors up to real-time requirements. A Comprehensible Guide To Controller Area Network represents a very thoroughly researched and complete work on CAN. It provides information on all CAN features and aspects combined with high level of readability. Book jacket.

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controller area network for dummies: Practical Motorsport Engineering Andrew Livesey, 2018-12-07 This guide and textbook on motorsport engineering is written from a practical point of view. It offers a wide-ranging insight into the nuts and bolts technology of practical car racing from saloons and sports cars to open wheelers. It gives the aspiring race engineer the tools to do the job by explaining all aspects of race car technology and offering crucial insight into the essentials of the motorsport engineering industry. For motorsport engineering students at all levels, this book particularly covers the examination syllabuses for IMI (the Institute of the Motor Industry), EAL and BTEC, and meets the CPD requirements of most engineering institutions. Each aspect of the race car is covered in a separate chapter with test questions and suggestions for further study at the end. Combining the key points from his previous publications Basic Motorsport Engineering and Advanced Motorsport Engineering, the author draws on a career in teaching and industry to create the must-have, all-in-one reference. It is an ideal companion for the practising owner, driver or race engineer (whether amateur or professional), a suitable introductory text for HND and degree students and a great point of reference for any other keen fans with an interest in motorsport.

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Electrical Systems Tom Denton ISBN: 978-0-08-096945-9 Automobile Electrical and Electronic Systems, Fourth Edition Tom Denton ISBN: 978-0-08-096942-8

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controller area network for dummies: Distributed Computing and Networking Vijay Garg, Roger Wattenhofer, Kishore Kothapalli, 2009-03-26 people volunteer their time and energy and work in a dedicated fashion to pull everything together each year, including our very supportive Steering Comm- tee members led by Sukumar Ghosh. However, the success of ICDCN is mainly due to the hard work of all those people who submit papers and/or attend the conference. We thank you all. January 2009 Prasad Jayanti Andrew T. Campbell Message from the Technical Program Chairs Welcome to the proceedings of the 10th International Conference on Distributed Computing and Networking (ICDCN) 2009. As ICDCN celebrates its 10th - niversary, it has become an important forum for disseminating the latest research results in distributed computing and networking. We received 179 submissions from all over the world, including Algeria, A- tralia, Canada, China, Egypt, France, Germany, Hong Kong, Iran, Italy, Japan, Malaysia, The Netherlands, Poland, Singapore, South Korea, Taiwan, and the USA, besides India, the host country. The submissions were read and evaluated by the Program Committee, which consisted of 25 members for the Distributed Computing Track and 28 members for the Networking Track, with the ad- tional help of external reviewers. The Program Committee selected 20 regular papers and 32 short papers for inclusion in the proceedings and presentation at the conference. We were fortunate to have several distinguished scientists as keynote speakers. Andrew Campbell (Dartmouth College, USA), Maurice Herlihy (Brown University, USA), and P. R. Kumar (University of Illinois, Urbana-Champaign) delivered the keynote address. Krithi Ramamritham from IIT Bombay, India, delivered the A. K. Choudhury Memorial talk.

controller area network for dummies: ARM Microprocessor Systems Muhammad Tahir, Kashif Javed, 2017-02-17 This book presents the use of a microprocessor-based digital system in our daily life. Its bottom-up approach ensures that all the basic building blocks are covered before the development of a real-life system. The ultimate goal of the book is to equip students with all the fundamental building blocks as well as their integration, allowing them to implement the applications they have dreamed up with minimum effort.

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articles grouped into sections for a cohesive and comprehensive presentation. The text contains 112 contributed reports by industry experts from government, companies at the forefront of development, and some of the most renowned academic and research institutions worldwide. Several of the reports on recent developments, actual deployments, and trends cover subject matter presented to the public for the first time.

controller area network for dummies: How To Use Automotive Diagnostic Scanners

Tracy Martin, 2015-08-01 From hand-held, dedicated units to software that turns PCs and Palm Pilots into powerful diagnostic scanners, auto enthusiasts today have a variety of methods available to make use of on-board diagnostic systems. And not only can they be used to diagnose operational faults, they can be used as low-budget data acquisition systems and dynamometers, so you can maximize your vehicle's performance. Beginning with why scanners are needed to work effectively on modern cars, this book teaches you how to choose the right scanner for your application, how to use the tool, and what each code means. *How To Use Automotive Diagnostic Scanners* is illustrated with photos and diagrams to help you understand OBD-I and OBD-II systems (including CAN) and the scanners that read the information they record. Also included is a comprehensive list of codes and what they mean. From catalytic converters and O2 sensors to emissions and automotive detective work, this is the complete reference for keeping your vehicle EPA-compliant and on the road!

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2013-12-05 This book addresses the various challenges and open questions relating to CAN communication networks. Opening with a short introduction into the fundamentals of CAN, the book then examines the problems and solutions for the physical layout of networks, including EMC issues and topology layout. Additionally, a discussion of quality issues with a particular focus on test techniques is presented. Each chapter features a collection of illuminating insights and detailed technical information supplied by a selection of internationally-regarded experts from industry and academia. Features: presents thorough coverage of architectures, implementations and application of CAN transceiver, data link layer and so-called higher layer software; explains CAN EMC characteristics and countermeasures, as well as how to design CAN networks; demonstrates how to practically apply and test CAN systems; includes examples of real networks from diverse applications in automotive engineering, avionics, and home heating technology.

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Systems and Dependability and Fault Tolerance Jens B. Schmitt, 2012-03-09 This book constitutes the refereed proceedings of the 16th International GI/ITG Conference on Measurement, Modeling and Evaluation of Computing Systems and Dependability and Fault Tolerance, MMB & DFT 2012, held in Kaiserslautern, Germany, in March 2012. The 16 revised full papers presented together with 5 tool papers and 5 selected workshop papers were carefully reviewed and selected from 54 submissions. MMB & DFT 2012 covers diverse aspects of performance and dependability evaluation of systems including networks, computer architectures, distributed systems, software, fault-tolerant and secure systems.

controller area network for dummies: Microcontroller and Smart Home Networks

Dawoud Shenouda Dawoud, Peter Dawoud, 2022-09-01 Over recent years industries have faced the problem of how to connect devices to 'speak' to each other with minimum wiring. Philips Semiconductors faced this problem when they needed to connect many ICs together. The Automotive Industry faced the same problem when it needed to connect tens of microcontrollers in each car. Recently, with smart homes, the problem has started to be part of each home. For instance, you may want to build your smart home with accessories from different manufacturers and you want the devices to 'speak' to each other. Added to that, you may want to control them from a central App or voice assist. Solutions for this problem started with the introduction of Inter Integrated Circuits (IIC) and Controller Area Networks (CAN). Both solutions are wired networks that allow ICs and microcontrollers to be connected in a network to communicate together. In smart home automation, a number of common smart home automation protocols that allow different

devices to speak and communicate together have appeared during the last few decades. Some of the smart home protocols come under the umbrella of what is called the "Internet of Things (IoT)". The proposed protocols can be grouped into wired networks e.g. X10, UPB; wireless or radio networks as ZigBee, Z-Wave, Bluetooth; or dual (wired and radio) such as Insteon. This book introduces to the reader some of the most popular Microcontroller and Smart home networks. The book covers in detail the following protocols: • I2C • I3C • CAN • ZigBee • ZigBee Pro • Z-Wave • Bluetooth Wi-Fi, WiMax and Insteon are part of our companion book "Serial Communication Protocols and Standards". This book gives detailed comparisons between the various protocols. To complete the knowledge of the reader, the book gives in the last chapter a short summary on the protocols that we did not fully cover in this volume: Ethernet, Thread, Insteon, X10 and UPB.

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 Welcome to ICOIN 2005, the International Conference on Information Networking, held at Ramada Plaza Jeju Hotel, Jeju Island, Korea during January 31-February 2, 2005. ICOIN 2005 followed the success of previous conferences. Since 1986, the conference has provided a technical forum for various issues in information networking. The theme of each conference reflects the historic events in the computer communication industry. (Please refer to www.icoin2005.or.kr for details.) The theme of ICOIN 2004, "Convergence in Broadband and Mobile Networking," was used again for ICOIN 2005 since we believed it was ongoing. This year we received 427 submissions in total, which came from 22 countries. Upon submission, authors were asked to select one of the categories listed in the Call for Papers. The most popular category chosen was network security, followed by mobile networks and wireless LANs. Other areas with strong showings included QoS and resource management, ad hoc and sensor networks, and wireless multimedia systems. From the outset, we could see where recent research interest lay and could make sure that the theme was still going in the right direction.

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 Control engineering seeks to understand physical systems, using mathematical modeling, in terms of inputs, outputs and various components with different behaviors. It has an essential role in a wide range of control systems, from household appliances to space flight. This book provides an in-depth view of the technologies that are implemented in most varieties of modern industrial control engineering. A solid grounding is provided in traditional control techniques, followed by detailed examination of modern control techniques such as real-time, distributed, robotic, embedded, computer and wireless control technologies. For each technology, the book discusses its full profile, from the field layer and the control layer to the operator layer. It also includes all the interfaces in industrial control systems: between controllers and systems; between different layers; and between operators and systems. It not only describes the details of both real-time operating systems and distributed operating systems, but also provides coverage of the microprocessor boot code, which other books lack. In addition to working principles and operation mechanisms, this book emphasizes the practical issues of components, devices and hardware circuits, giving the specification parameters, install procedures, calibration and configuration methodologies needed for engineers to put the theory into practice. - Documents all the key technologies of a wide range of industrial control systems - Emphasizes practical application and methods alongside theory and principles - An ideal reference for practicing engineers needing to further their understanding of the latest industrial control concepts and techniques

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 This book constitutes the refereed post-conference proceedings of the Fifth International Conference on IoT as a Service, IoTaaS 2019, which took place in Xi'an, China, in November 2019. The 54 revised full papers were carefully reviewed and selected from 106 submissions. The papers contribute to the discussion on the challenges posed by Internet of Things (Io). The two technical tracks and three workshops deal in detail: Networking and Communications Technologies for IoT, IoT as a service, International Workshop on Edge Intelligence and Computing for IoT Communications and Applications, International Workshop on Wireless Automated

Networking for Internet of Things, and International Workshop on Ubiquitous Services Transmission for Internet of Things.

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