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Research, challenges and opportunities in software define radio technologies

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ABSTRACT

The network extended not just internationally but also throughout a broad variety of application areas in this age, with healthcare being one of the most well-known and vital industries. Improvements in healthcare are possible if we start using the popular internet of things (IoT) technology as a key instead of focusing on other disciplines. Wireless body area network (WBAN) is a field in which we communicate with a network of human people and medical equipment that may be used in conjunction with internet of things technology to perform any function. Additional features for software defined networks will be added in the future. In the event of a critical crisis, the suggested suggestions will be to take care of the patient's life. Because the fitted equipment keeps a lot better eye on the patient than previously advised methods. This study combines WBAN, IoT, and software defined network (SDN) to make sense in the healthcare field.

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1. INTRODUCTION

In addition to people, machines, and things, the next generation of mobile radio systems is anticipated to provide wireless connection for a broad variety of new applications and services. the internet of things (IoT), a unified ecosystem, will be created in the coming years when hundreds of billions of inexpensive, low-complexity devices and sensors are linked to the network internet of things. As a consequence, the 3rd generation partnership project (3GPP) will standardise narrowband-IoT (NB-IoT) in 2016, a brand-new narrowband radio technology created just for the IoT. In addition to assuring harmonious coexistence with current general packet radio service (GPRS), global system for mobile (GSM) and long-term evolution (LTE) systems, this new radio interface strives for huge connectivity, decreased UE complexity, coverage expansion, and deployment flexibility. Recent years have seen a major revolution in radio systems engineering due to the use of open-source software and software defined radio (SDR) technologies. To analyse, evaluate, and test new wireless network technologies, researchers may utilise these systems as a testbed for experiments and prototype development. The purpose of this thesis (OAI) is to develop the NB-IoT stack of protocols on the EURECOM open-source software platform. The primary goal of the mission's first phase is to link OAI with NB-radio IoT's resources control capabilities. New radio resource configuration (RRC) levels coding structure, interfaces, and a cutting-edge technique for managing signaling radio bearers are shown once the platform architecture has been described. After a detailed analysis of system information scheduling, a sub frame-based sending approach is suggested. The last section of this thesis examines how to develop a multi-vendor platform interface using the small cell forum's functional application platform interface (FAPI) standard. Between the medium access control (MAC) and design of physical (PHY) layers of OAI, there is a programmable and dynamically loadable interface module (IF-Module). Primitives and related code structures are defined, along with data and configuration actions. The convergence of NB-IoT and FAPI standards [1]-[5] necessitates redesigning physical layer techniques and creating a downlink transmission system.

Businesses and academia are both interested in the fast developing IoT platform. By 2020, it's predicted that 50 billion devices will be connected to the internet, up from the current estimated 15 billion. Resource allocation, data flows, and authentication in the IoT network are all problems because of the enormous amount of data that these IoT devices create. As an alternate approach to address IoT issues, functionality and centralised control are being studied. A software defined network (SDN), on the other hand, offers centralised and customised network administration while needing no modifications to the current network architecture. The combination of IoT and SDN is examined in this article. For the years 2010–2016, a thorough assessment and general solutions are provided for the different communication domains. Along with current research trends and contributing factors from the future, the paper also provides a critical examination of IoT and SDN technologies. An easy-to-understand picture of the changing patterns may be obtained by comparing the various SDN-based IoT deployment choices. The study concludes by making prognoses for the future and providing a qualitative evaluation of the state of the globe in 2020.

Exciting possibilities for linking physical items already exist because to technological advancements and telecommunications infrastructure. Wide area networks (WANs), actuator, mobile, embedded devices, and even cross-infrastructure linkages are all emerging as new connectivity options. Device-to-device (D2D), machine-to-machine (M2M), vehicle-to-vehicle (V2V), and so forth. In addition, it is claimed that these gadgets will be web-connected, leading to the IoT or, used more broadly, the internet of everything (IoE) [6]-[10]. In a linked world, IoT devices include wireless devices, radio frequency identification (RFID) devices, actuators, and network gadgets. A new sort of connection called the IoT allows a smart environment. By changing the way we think about interacting with an object in our surroundings, it enhances our quality of life. Due to the enormous amount of data created, IoT is lacking in automation, speed, safety, and information management. The utilisation of programmability and centralised control in IoT administration is expected to be advantageous to customers. The high-level implementation of low-level forwarding devices is hidden by SDN's separation of the control plane and data plane. We examined the possibilities for incorporating SDN control plane into IoT networks in this article. In this article, we first looked at the current state of IoT management based on SDN centralised control plane in various IoT contributors, summarising architectural details and development, and then we went into detail about the remaining challenges in this merger and provided some global forecasts for 2020.

2. SOFTWARE DEFINED RADIO NETWORK

Wireless body area networks (WBANs) have taken a lot of interest from academics and industry. A WBAN is a network specialised to collecting individual biological data through sensors and transmitting healthcare-related instructions to certain sorts of actuators for health-related goals. Even yet, there are a variety of proprietary designs, which might lead to skewed results. This study investigates the function of SDR in a WBAN system for in and out patient monitoring, as well as explaining the value of SDR in WBANs to health professionals.

The reliance on hardware in all wireless networks is a source of worry, since it restricts reprogramming and reconfiguration options. There is usually no way to address system vulnerabilities if a mistake occurs in the equipment, firmware, or software. SDR eliminates a variety of fixed-hardware issues while also providing additional advantages. There are increasing medical sector dynamism and net convergence as a result of the SDR, according to stake-holders. Through rearrangements of modules, updating, and elasticity, the SDR paradigm may give creativity to the compatibility of medical subsystem. The IoT relies on radio frequency (RF) technologies to achieve its long-range, low-power capabilities. IoT is changing for the better with the introduction of 5G RF technology, however some may find it challenging to take advantage of the newest and finest. RF communication is at the heart of the internet of things [11]-[15]. 5G RF technologies in IoT are fast evolving to unite high bandwidth, low latency, and long-range applications, and we may anticipate to witness their disruptive implications on a variety of sectors in the near future! In the meanwhile, current technologies and protocols like as long range (LoRa) and LoRaWAN enable IoT devices to transmit data over great distances, although at reduced bandwidths.

The internet of things in agriculture allows for the optimization of agricultural production through precision farming, which involves the careful monitoring and control of a variety of environmental conditions, including temperature, light levels, atmospheric composition, and water usage. Other agricultural uses may include asset monitoring and smart irrigation, allowing for the management of vast swaths of agriculture from a single location. Precision farming, such as monitoring the status of individual animals in real time, may now be done on a far bigger scale because to the high speeds provided by 5G. By incorporating IoT into traffic lights, street lighting, and trash management, smart cities offer a larger, more connected cyber physical environment in which to live. This enables data-driven choices to be made to improve operations and save expenses, such as the environmental consequences of idle traffic. The interconnection of smart cities will become more common than ever before with 5G as a standard for wireless communication across mobile phones, PCs, and IoT devices!

With 5G RF technology enabling reduced latency transmission, remote robotics is no longer a pipe dream. 5G will allow robotic surgery in the healthcare industry by offering high-quality video streaming and real-time control. Remote control robots, from the other hand, will make infrastructure and rescue operations safer in hazardous large factories or conflict zones. Rise of the IoT and industrial internet of things (IIoT) a wave of innovation is trying to sweep the marketplace, linking an eco-system of sensing devices, gadgets, and machinery to a network that guarantees to endorse resource utilization, operational efficiencies, and productivity. The number of linked "things" is expected to approach 25 billion by 2020, presenting a potential to change how enterprises are run. Gateways, sensors, infrastructure, and some of the parts of the IoT ecosystem, big data and analytics are shown in Figure 1. The simplest way to summarise it was said by a speaker at a recent IoT conference: "Big Data will be Big!". It is important to note modelling of substantiating data analytics, whether this resides in the cloud or at the edge, companies can quickly make a diagnosis and troubleshooting not just to one‘s smart sensors from the proactive maintenance point of view, but also their operations.

While the ecosystem may be hardwired, most people choose a mixed approach. WSN and most network architectures are accessible via speeded broadband connections. Despite the fact that RF technology is a part of our daily life and has been used in some of the toughest environments for decades in the context of IIoT, many people still see wireless technology as creative. The goal of this article is to demystify the issue by showing how the same essential ideas apply independent of the RF technology used in IoT installations.

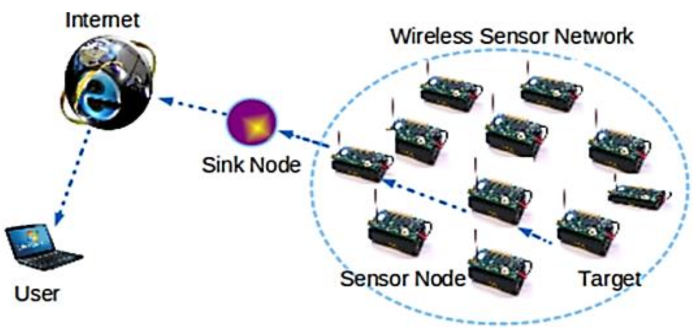

Figure 1. SDN network based wireless sensor networks

Wireless IoT devices may last for years and can be placed almost anywhere. New applications may need the usage of these devices in very challenging RF environments. For example, smart meters located in basements must be able to withstand difficult coverage circumstances. Factory-floor robots must contend with extreme radio circumstances while maintaining dependable, low-latency connectivity. Other devices, such as linked mousetraps or parking lot sensors, must be very durable and waterproof, which makes the entire RF design difficult. The wireless connection performance of IoT devices is a critical aspect in the success of IoT applications. Otherwise, crucial performance characteristics like dependability, power consumption, latency, and coverage may suffer [16]-[20]. Routing protocol for low-power and lossy networks (RPL) was developed by the internet engineering task force (IETF) as a routing architecture for the IoT. RPL allows for one-to-many, many-to-many, and many-to-one communication. According to recent research, RPL performs badly in many-to-many and one-to-many communications because of the higher control cost involved with finding many-to-many and one-to-many forwarding channels, as well as its non-storing manner of operation (MoP). We provide an internet of things routing framework (IoT-RF) in this paper that enables many-to-one, many-to-many, and one-to-many communications. To overcome the memory constraints of the storage MoP, the framework collaborates with it and suggests a network of gateways. Two protocols are included in the framework for locating many-to-many and one-to-many forwarding channels, respectively. One of the recommended protocols finds many-to-many and one-to-many forwarding connections using many-to-one communication; as a result, the protocol doesn't have any additional control overhead. Using empty control messages, the other protocol looks for many-to-many and one-to-many forwarding paths. IoT-RF was mostly developed using Contiki OS. Comparing "IoT-RF to a de facto IoT routing system" is achievable using Cooja-based emulation testing. In terms of packet delivery ratio, end-to-end packet delivery delay, and control overhead in many-to-one, many-to-many, and one-to-many communications, our IoT-RF significantly surpasses the de facto routing design, according to our results. The proof-of-concept was built on a small number of 8-channel private mobile radio use-cases.

Every radio has the capacity to perform a variety of useful activities for the user and network due to the intricacy of radio communication at this stage. It may also aid in reducing spectrum congestion. A perfect software-defined radio, or cognitive radio in a broader sense, would include all the advantages of software defined radio with artificial intelligence (AI) by adopting advantageous wavelengths and waveform to reduce and minimise interference with current radio communication systems. The work that is being presented is based on spectrum sensing and is backed by simulation findings. Spectrum sensing is carried out using a matching filter. A high-performance SDR that is seamlessly connected with state-of-the-art deep learning hardware is called the deepwave digital artificial intelligence radio-transceiver (AIR-T). This RF module combines a fast USB 3.0 connection with the AD9371 RFIC transmitter and a reprogrammable Xilinx 7 field-programmable gate array (FPGA). A continuous frequency coverage range of 300 MHz to 6 GHz is provided by the AIR-T module. One RF module houses the three digital processors (FPGA, graphics processing unit (GPU), and central processing unit (CPU)). The AIR-T module has a Mini-ITX form factor and uses 22 W of power to operate. A new "AIR-T Edge" series product from deepwave digital is the AIR8201. The AIR8201 AIR-T is superior to the AIR8201 in that it has a sturdy case, more receive gain, better noise figure, a global positioning system (GPS) controlled oscillator, and a broader frequency range. The AIR8201 increases the AIR-versatility T's by making it possible to use an industrial SDR for edge data processing, adaptive communications, spectrum management, and "signals intelligence."

3. CHALLENGES OF SOFTWARE DEFINED RADIO

The use of waveforms for communications, both military and commercial, has established SDR as the de facto industry standard during the last 30 years. At that time, the need to fully realise waveforms in software running on "general purpose processors (GPPs)" had to be balanced against "size, weight, and power (SWaP)" limitations. As a result, compute-intensive portions of the waveform software had to be run on hardware like "field programmable gate arrays (FPGAs)" or "hardened IP accelerators." Recently, research activities in AI and machine learning (ML) have become more widespread across the world. A new desire for ML/AI approaches to be fully implemented in software has emerged with the advent of open source machine learning frameworks like PyTorch and TensorFlow. This need must be balanced against SWaP restrictions, particularly for inference at the edge. Fortunately, this problem's solution has been significantly influenced by technological advancements in both the semiconductor and tool sectors. The "adaptive compute acceleration platform," a novel kind of heterogeneous processor, will be discussed in this session.

Standard RGB cameras combine the number of pixels to produce RGB colour, therefore three separate cameras with varying band pass filters that allow just the necessary colour signal to penetrate the sensor are needed to represent each colour in each pixel separately. The most challenging part of constructing such a system is calibrating the cameras and creating a platform that can read data from several sensors and aggregate the outcomes. The CubeSat's short access time and slow data transfer speed are its other issues. In addition, the CubeSat's quick speed results in noisy photographs and fuzzy photos. Additionally, in certain cases when it is overcast, the captured images only include clouds. Consequently, it is desirable to have an intelligent system that can classify photographs as worthwhile for downlink or not utilising machine learning methods. Images with value are crystal clear, blur-free, and cloud-free.

SDR is a transceiver that can be programmed to execute a number of wireless communication protocols without needing to make any hardware upgrades or adjustments. With a stronger emphasis on programmability, flexibility, portability, and energy efficiency, advancements in the SDR industry have led to a surge in protocol development and a wide variety of applications in cellular, WiFi, and M2M communication. As a consequence, SDR has garnered a lot of attention and is significant for both academia and business. SDR's creators want to simplify the implementation of communication protocols while enabling academics to test concepts on operational networks. This paper provides an overview of the most recent state-of-the-art SDR systems in the context of wireless communication protocols. Our discussion of significant design trends and development tools is immediately followed by a study of the SDR architecture and its key elements. We also employ a set of measurements to show how there are significant disparities in the energy, computing power, and physical space used by different SDR systems. We also examine existing SDR systems and provide a comparative analysis for programmers to utilise. We next list a few pertinent study areas and provide a description of potential solutions. We provided an in-depth analysis of the various design methodologies and hardware frameworks utilised in SDR systems. Examples of this include co-design, GPPs, GPUs, digital signal processors (DSPs), and FPGAs. We went through the basic architectural types, their advantages, and disadvantages. It was required to compare them based on their processing speed and energy efficiency because to the variances in design methods. The most important previous and present SDR systems were then reviewed, whether they were developed by business or by academia. In our last discussion, we covered some of the research issues and topics that are anticipated to advance SDRs and gain mainstream adoption in the near future. We predict that SDR solutions will become commonplace and that their high levels of adaptability and programmability to a wide range of wireless communication protocols will become the standard. This article explores this phenomenon in detail, as well as its supporting technology, applications, and continuing study, from a variety of angles.

The separation of forwarding and control functions is a feature of the relatively new SDN communication network concept. The network's intelligence is moved to an SDN controller that is conceptually centrally placed. This controller communicates with data-plane devices, maintains a broad view of the network, and provides a programming interface for network management applications. The potential of this idea may be seen in the possibility of traffic engineering and resource management being carried out more successfully in a centralised system with insight into application demands and all available resources. SDN and fog computing are used in the recommended IoT architecture to support applications that need mobility and low latency. Despite the fact that these technologies' benefits have received widespread recognition in the scientific community, there are still a number of barriers preventing their widespread use. This study's objective is to demonstrate how SDN and fog computing may be successfully paired to overcome each other's weaknesses.

The proposed IoT architecture aims to solve the fog orchestration with SDN problem as well as the SDN scalability problems with fog computing. To address current agricultural challenges, such as the need to strike a balance between output and environmental concerns, precision agriculture leverages contemporary information and communication technologies. The applications of this scenario are made feasible by ad-hoc wireless sensor and actuator networks (WSANs), which are used to measure/monitor certain environmental parameters and impose control decisions. The Cloud application uses the data gathered by the sensor nodes to make intelligent control decisions that should lead to better and more crops by ensuring that water, herbicides, and fertilisers are administered properly. With a fog node installed at the network edge, the local application instance may instantly understand the data gathered, control the measurement process, the stability and oscillatory behaviours, and transmit commands to actuators (such as irrigation valves). The fog programme has the option of removing unnecessary data packets and sending the combined data to the cloud for long-term analysis. One of the apps that might be utilised on the fog node is a local SDN controller. The automated configuration of WSNs and best feasible management of energy-limited sensor nodes with constrained communication capabilities would be the responsibility of this initiative [21]-[25].

To overcome these limitations in traditional networks, a novel concept known as SDN has been created. Network control may now be separated from traditional hardware devices thanks to the new network architecture known as SDN. Because of this, the main objective of the SDN is to separate the control plane from the data plane, which contains the forwarding devices. As a result, depending on the requirements of the individual application, suitable control logic for physical devices may be constructed in real-time. Infrastructure, control, and application are the three primary categories that make up SDN. SDN includes a number of application programming interfaces (APIs), including northbound, southbound, eastbound, and westbound. The application layer and the control layer are linked via the northbound API, enabling communication between them. Through the northbound API, the network's abstracted image is also made available to the application layer. The southbound API is responsible for bridging the gap between the control and infrastructure layers by enabling controllers to install different rules in forwarding devices like routers and switches and for enabling those devices to communicate with the controller in real time. In order for different controllers to make decisions together, the eastbound and westbound APIs are responsible for bridging the gap between them. OpenFlow is the most used protocol for facilitating communication across the control and data planes. The IoT is a quickly developing technology that enables diverse objects, such as sensor nodes, embedded systems, and intermediate devices, to collect and exchange data in order to realise the objectives of a fully interconnected world in the near future. For real-time applications like smart energy, intelligent transportation, and smart health care, an IoT architecture is often made up of several sensor and

RFID nodes that form large-scale distributed embedded systems. Even while devices are capable of performing many jobs, traditional network systems' preset programmed nature forbids them from doing so. It is important to virtualize device functionality and update it in real time as a consequence. Network function virtualization (NFV) is a newly developed concept that allows devices to execute a variety of tasks while modifying their functionality in real time depending on application-specific requirements. The separation of the control plane from the physical devices from the perspective of SDN makes NFV for internet service providers easier. The usefulness of a network may be decreased by under- or overusing its resources and reducing its performance. Effective mapping of users' requests is thus crucial for increased resource efficiency and network utility. The improved use of network resources in SDN is made possible by flow-rule-based traffic forwarding. Because of the SDN controller's flow-rules, requests from different users may be forwarded along the desired path.

To manage the enormous quantity of data collected from billions of devices, IoT will need a significant number of data centres. As a consequence, data centres will use enormous quantities of electricity. Smart energy management technologies are thus necessary for energy-efficient data centre networking. In SDN-based data centre networking, traffic may be efficiently directed to the right servers. As a consequence, energy-efficient data centre networking is possible since the devices in the data centre may be switched on and off dynamically depending on the demands. A network of IoT devices could find use for this functionality. Finally, the security of the devices and network is required in order to support several devices, vendors, and users on a single platform. For instance, a number of gadgets are connected to a certain service provider. The only person who should be able to control such devices is the particular service provider. Other service providers should not be able to access the data generated by the devices even if they have access to the data. Consumers in an IoT network are fundamentally concerned about privacy at the same time. The privacy of customers may be violated since multiple authorities may have access to information about who is doing what due to the integration of many devices into a single platform. Therefore, in order to safeguard users' privacy when integrating diverse devices into a unified platform, researchers must take into consideration such eventualities. The security and privacy of network traffic are enhanced by SDN's fine-grained flow control. Giving an RF to IoT SDRs is the first technology hurdle in realising the concept since smartphones do not directly link any of their radio front ends to the application processors. The availability of a plug-in RF module has not changed despite the fact that smartphone manufacturers began promoting swappable plug-in hardware modules in 2016. So, in order to demonstrate the principle, we connect a smartphone to an external RF. For connecting to the external RF, the only wired interface available on modern smartphones is the universal serial bus (USB) interface. It's not intended to be a preferred configuration, only a workaround that comes the closest to the alternative design we provide. The external RF is only used for analogue signal processing, such as frequency up/down-sampling and "analog-digital and digital/analog conversion (ADC/DAC)", not for digital signal processing. All baseband signal processing for the physical layer is carried out by the SDR running on the application processors, with continuous coverage from 70 MHz to 6 GHz. The smartphone may act as a host for the USRP device by using USB on-the-go (OTG), which is another option. Unfortunately, while utilising an OTG connection, mobile phones only support USB 2.0, although other devices can use USB 3.0. It limits USB bandwidth to a maximum of 32 MB/s despite USB 2.0 having a maximum raw throughput of 480 Mb/s because of overheads.

The internet of things is becoming more approachable because to the cloud-based IoT service prototype known as "sensing as a service (SaS)". In order to meet the demands, it may also make it easier for the efficient transmission of sensor data to different stakeholders on demand via a data stream. The IoT consists of readily identifiable, digitally networked objects or smart devices that can recognise, process, and interact with events. A smart device application based on the IoT domain (ecosystem) may be created by merging the services of smart devices. To perform IoT-related tasks, smart device sensors are used. As they roam about their deployment area, these sensors gather data. Data distribution and collection are managed by the cloud, and data collectors or sensors obtain the necessary information via a pay-as-you-go IoT application. In order to enhance prediction services' accuracy and optimise network operations for effective automation, real-time data acquired from sensor devices is monetized and transformed into new data streams. The key components of the sensing model need efficient search methodologies and effective sensing algorithms in order to provide the sensing service.

A part of the IoTs called sensing is the process of obtaining information from smart devices linked to a network. The IoT era is characterised by connectivity, and APIs enable users to connect to one another and combine services. The analysis, organisation, use, and acquisition of data remain the most pressing concerns for the IoT. The various approaches in the literature reveal that IoT and cloud have a number of complementary properties, and there is a need to organise and construct IoT such that these systems may benefit from the nearly endless capabilities that cloud computing can provide, for example, to compensate for smart device technological limitations (storage, computation, and energy consumption). The cloud may serve as a temporary layer between IoT devices and apps so that resources are appropriately managed.

4. CONCLUSION

Several sensors are connected to the internet through the IoT, a current hot technology that enables effective and appealing asset management in a smart environment (viz., Smart Home, and Smart city). Platforms, infrastructures, and programming tools are offered as services using cloud technology. Using the IoT's global resources, SaS is a kind of advanced distributed computing that enables the creation of a shared sensor network that can be used as a service. These services are available for usage by businesses and developers, providing users the opportunity to monetise their data using existing infrastructure. Additionally, the SaS paradigm concept has to be looked at and analysed in light of IoT technology. The main objective is to examine the innovative, social, technological, and ideological merits of the SaS paradigm. In this in-depth survey, we look at different sensing framework paradigms and give a comprehensive overview of the various difficulties and problems that come up when creating the ideal framework that satisfies the needs of all the stakeholders (users, developers, operators, and organisations) in the most effective way possible.

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