IEEE CONSUMER TECHNOLOGY SOCIETY (CTSOC)

ISSUE: DECEMBER 2021

CTSOC-NCT NEWS ON CONSUMER TECHNOLOGY

Application scenario of the iBuffet system

TABLE OF CONTENTS

EDITOR'S NOTE

On behalf of the Editorial Board of IEEE CTSoc News on Consumer Technology (NCT) editor-in-chief Wen-Huang Cheng and editors, Luca Romeo and Pham The Bao, I am delighted to introduce the second issue of the News on Consumer Technology (NCT).

This issue starts with a cover story which shows an application scenario of the iBuffet system for calorie intake control published in the CTSoc's iconic journal, IEEE Transactions on Consumer Electronics, as a demonstration of AIoT (Artificial Intelligence (AI) and Internet of Things (IoT))-based intelligent management system using consumer technology for healthcare usage.

Next, the feature people provide an interview with research team of Advanced Telecommunications Research Institute International (ATR), Wave Engineering Laboratories, Kyoto, Japan. As one famous research institute in Japan, ATR dedicates to the fundamental researches on computational neuroscience, deep interaction science, wireless and communications and life science. This issue shares how this famous research institute creates new wireless technology and trains the qualified wireless researchers.

Finally, this issue presents a featured article brought by Dr. Ted Chang, the Chief Technology Officer of Quanta Computer Inc, and Lifetime Chair Prof. Yi-Bing Lin of National Yang Ming Chiao Tung University (NYCU), discussing on the AIoT (Artificial Intelligence (AI) and Internet of Things (IoT)) for Digital Transformation of Healthcare. The article introduces how to employ AIoT to realize the prediction, prevention, precision and personalization for future smart medicine, which is very important issue under pandemics.

Yafei Hou

Editor of NCT

We hope you can enjoy your reading!

ARTICLE TITLE
iBuffet: An AIoT-Based Intelligent Calorie Management System for Eating Buffet Meals with Calorie Intake Control

AUTHOR(S)
Wan-Jung Chang, Liang-Bi Chen, I-Chen Lin, and Yang-Kun Ou

JOURNAL TITLE
IEEE Transactions on Consumer Electronics

Date of Publication
December 2021

Currently, in-office employees in industrial society often eat for three meals daily since they are busy working. However, this diet is high in sugar, salt, and oil. Moreover, it is impossible to manage daily calorie intake. When a person doesn't know how to choose the food in a healthy way, many health problems can result. Thus, to eat buffet meals with calorie intake control, an intelligent calorie management system, named iBuffet, is proposed by combining artificial intelligence and Internet of Things (AIoT). The iBuffet system consists of four main components, such as an intelligent buffet table modules, an AI Wi-Fi base station, an mobile device application (app), and a cloud-base health management platform. Further, the proposed system aims to improve consumer dining health through calorie intake calculation by recording daily meals via mobile device app. Afterward, the information is sent to the cloud-based platform for user health management. During testing, the iBuffet system can recognize 30 kinds of meals within 1s which is so practical for an actual buffet restaurant.

INTERVIEW WITH RESEARCH TEAM OF ATR WAVE ENGINEERING LABORATORIES, KYOTO, JAPAN

EDITOR: YAFEI HOU

Editor Note: As one famous research institute in Japan, Advanced Telecommunications Research Institute International (ATR) dedicates to the fundamental researches on computational neuroscience, deep interaction science, wireless and communications and life science. In this issue, the editor interviewed with the research team of Wave Engineering Laboratories (WEL), one Laboratories of ATR, to share how this famous research institute **creates new wireless technology** and **trains the qualified wireless researchers**.

Director, Dr. Yoshinori Suzuki

He received the B.E., M.E. and Ph.D. degrees from Tohoku University, Sendai, in 1993, 1995 and 2005 respectively. Currently, he is the director at ATR Wave Engineering Laboratories, Kyoto, Japan.

Vice Director, Dr. Toshikazu Sakano

He received Ph. D degree in electrical and communication engineering from Tohoku University in 1998. Currently, he is the vice director at Wave Engineering Laboratories and a director of Business Development Office, ATR.

Dept. Head, Dr. Kazuto Yano

He received Ph. D degree in communications and computer engineering from Kyoto University in 2005. Currently, he is the Head of Dept. Wireless Communication Systems at Wave Engineering Laboratories, ATR.

Principal Researcher, Dr. Satoru Shimizu

He received Ph. D. from Chiba University in 1995. Currently, he is the principal researcher at Wave Engineering Laboratories ,ATR and a visiting professor of Doshisha University.

[Q1]What are the major missions and main research topics of ATR-WEL? What is important role of ATR-WEL in Japan?

[Dr. Suzuki] Our Laboratories will fulfill the following three missions.

・Creation of advanced technology to solve unexplored issues in the wireless field

・Providing new value by utilizing wireless technology in new areas

・Training of stubborn wireless researchers and technicians who strongly promote new R&D based on free and original ideas.

Therefore, our major research projects are aiming to improving communication quality such as large capacity, multiple connections and low latency, as major targets of 5G. Wireless has many issues to be solved and new roles to be expected. For example, there are wireless harnesses that never cause physical disconnection, monitoring technology that can easily observe the radio environment, and non-contact sensor that grasps the state and properties of objects using radio waves, etc.

Our Laboratories aims to achieve pioneering and original research on wireless technologies and services for our future society. Most projects are supported from government, and R&D activities are operating with industry-academia-government collaboration as well as international collaboration.

[Q2] What are the main research directions of wireless technologies for the next decade from the views of ATR-WEL?

[Dr. Suzuki] From my view, ATR-WEL will focus on following research topics:

Wireless network control technology and frequency utilization technology: By switching the frequency and communication path according to noise, interference, time / frequency / polarization, and environment, it can improve the overall frequency efficiency and the convenience of communication.

Antenna control technology: It aims to improve communication quality by controlling the directivity and polarization of the antenna.

Wireless harness technology: We try to make wiring of information and power inside equipment wireless.

Radio environment monitoring and sensing technology: Interference waves that may affect communication are measured and analyzed, and the sources are identified. Radio waves sense without contact and provide correct information to networks and mechatronics equipment.

[Q3] Compared with the education provided from universities, what are the major advantages of training wireless researchers at ATR-WEL?

[Dr. Suzuki] Most of our research projects are from government, and R&D activities are operating with industry-academia-government collaboration. Therefore, we offer young wireless researchers the first-class, timely and practical research topics from many hot wireless fields such as IoT, AI, and 5G/6G. In addition, researchers and engineers with various experiences and achievements can provide appropriate advices for young wireless researchers.

From our training, we hope the young people can become a full-fledged researcher through daily practical research and development through joint research and contract research, and exchanges with many people in R&D, conference presentations, exhibitions, etc.

[Q4] Could you introduce the major research contents of Dept. of Wireless Communication Systems?

[Dr. Yano] We are engaging for research on wireless communication technologies in PHY and MAC layers to improve efficiency of radio spectrum utilization for improving quality-of-service (QoS) of users and for increasing the number of accommodatable uses number. For example, multiple-input multiple output (MIMO) transmission and interference suppression technique are our major research topics in PHY layer. Design of efficient channel access protocol for unlicensed bands is a major research topic in MAC layer. Moreover, we are also engaging for research on prediction of wireless channel usage and QoS that will contribute to realizing efficient control/management of wireless communication systems/networks.

[Q5] In your opinion, which research topics are more important and practical for next 6G wireless communication systems?

[Dr. Yano] In 6G era, wireless communication networks need to support various applications which are important and critical in our social lives or in industries. To support such applications with severe QoS requirement, technologies to realize deterministic communications, especially in wireless communications, to guarantee QoS required by users/applications will become more and more important.

[Q6] For next decade, the technologies of AI and IoT will be definitely driving forces for future wireless system. In your opinion, how do you think these technologies will change the research directions of wireless communications and smart device of consumer electronics?

[Dr. Yano] The usage of wireless communications will become more and more complex because there is a variety of applications that have different traffic patterns and QoS requirements, even in IoT use cases. AI will be a key technology to provide automatic control/management of wireless communication networks, especially in such complex traffic situations. So, AI may free engineers/operators from finding sophisticated rules to efficiently control/management wireless communication networks in future. On the other hand, AI will not be omnipotent, and there will be some limitations of AI. So, researcher will be requested to analyzes the AI's limitations and explained them to the world.

[Q7] Could you introduce the major research contents of Dept. of wireless applications?

[Dr. Shimizu] I am researching robot control using millimeter-wave band communication and proximity sensors using changes in antenna characteristics.

[Q8] In your opinion, what the technology trends for the future wireless applications?

[Dr. Shimizu] I think that terahertz band communication for beyond 5G and non-contact sensing for COVID-19 countermeasures are technological trends.

[Q9] Could you provide some comments on the integration of wireless applications on smart devices or consumer electronic equipment for Society 5.0?

[Dr. Shimizu] In addition to communication and control, I think that application technologies that transmit electric power wirelessly will advance.

[Q10] Could you introduce the wireless COE project at ATR-WEL?

[Dr. Sakano] The Wireless COE R&D Program is a program in the Strategic Information and Communications R&D Promotion Program (SCOPE) of the Ministry of Internal Affairs and Communications (MIC). ATR, in collaboration with Kyoto University, proposed a project;“ R & D on technologies for robust / flexible radio resource utilization and new applications, and its support program for training of radio experts,” to the MIC’s program and was accepted (SCOPE No.196000002) in 2019.

Since then, we have run five R&D sub-projects related to the creation of advanced wireless technology and applications in the wireless technical field as joint projects with academia, industry and startup company. One of the main objectives of the program is to encourage young wireless talents and get them grow to top researchers/engineers through conducting the sub-projects as leaders. Other objectives of the project are to create advanced wireless technology and to develop new application areas for wireless technology.

To support the R&D sub-projects and to accelerate wireless related R&D nationwide, we installed two functions in the project. They are the assignment of mentors to facilitate and encourage talents and the release of a part of ATR’s facilities to the leading wireless related R&Ds in and around the project.

The project assigned fourteen experts as mentors from wide variety of related technical fields like wireless network, communication protocol, radio-wave propagation, antennas, microwave circuit, semiconductor device, EMC, satellite communication, international standardization, and technical magazine editor. The mentors support the R&D sub-projects. They make presentations as mentors in technical seminars and workshops held in and around the project.

ATR originally owned facilities and equipment to conduct R&D on wireless technology. In the wireless COE project, we renewed them so that top researchers can use them for their leading R&D. The facilities are a large anechoic chamber, CAD for semiconductor design, 3D printer, Software defined radio equipment and various measurement equipment. After the start of the project, leading researchers from universities and companies often come to ATR to conduct their experiments using the facilities and equipment.

We hope that the COE project not only yields the technical outcome through the pre-project’s R&D, but also create new talents for the future of this technical field. In addition, we expect ATR keep contributing to the evolution of this technical field as center of excellence even in 6G era and beyond.

[Q11] What are the advantages of wireless COE project?

[Dr. Sakano] An advantage of the wireless COE project run by ATR and Kyoto University is that we have abundant accumulating experience and outcome, and environment to run wireless related leading-edge R&D. A substantial human network in the researcher/engineer community has been formed through the R&D activities conducted for decades. This human network is another advantage we have. The network often makes it easy for us to reach industry, government and academia nationwide and global to form a collaborative R&D project, to get fund to run R&Ds and to deploy R&D outcome in real society. We believe the wireless COE project would be a good trigger to create an eco-system which keeps generating talents and also new technologies in the field of wireless technology.

AIoT FOR DIGITAL TRANSFORMATION OF HEALTHCARE

Ted Chang, Ph.D.
CTO, Quanta Computer Inc.
ted.chang@quantatw.com

Yi-Bing Lin
Lifetime Chair Professor, College of Computer Science, NYCU
liny@nctu.edu.tw

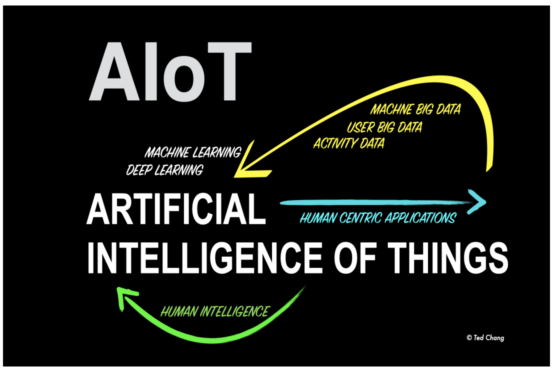

Fig. 1. Future smart medicine on prediction, prevention, precision and personalization

Introduction

The world is facing critical challenges from COVID-19 pandemics. Social distancing is changing our lifestyle. Working from home, on-line education is becoming the new normal of our society. Both medical and healthcare need to be transformed in order to provision precision and personalized medicine over the cloud under drastic medical resource shortage due to pandemics. In this paper, a novel end-to-end AIoT cloud platform of both Artificial Intelligence (AI) and Internet of Things (IoT) is proposed to address the critical healthcare transformation problem under pandemics. The value of traditional IoT is actually on the “Internet” of big data generated by the “things”, while the value of the data is the intelligence created through machine learning or deep learning. Such AI is the core value of AIoT for the healthcare of the future.

Smart Medicine for the Future

To achieve the goal of future smart medicine on prediction, prevention, precision and personalization as in Fig. 1, the big data of the electrical medical record (EMR) in the hospitals, the vital sign data from new wearable medical devices or Internet of Medical Things (IoMT) [1] and even genetics of the patients need to be well managed and analyzed to optimize the patient care. Thanks to the recent development of cloud computing, secure storage and scalable computing for such big data analytics is no longer insurmountable. Moreover, the progress of machine learning and deep learning makes medicine and healthcare even smarter through AI [2]. The ultra-high bandwidth and low latency of 5G connectivity make the edge AI for time critical medical applications become possible. To sum up, an end-to-end AIoT platform which comprises AI, Big Data, Cloud Computing, Devices and Edge Computing would be essential for future smart medicine (see Fig. 2).

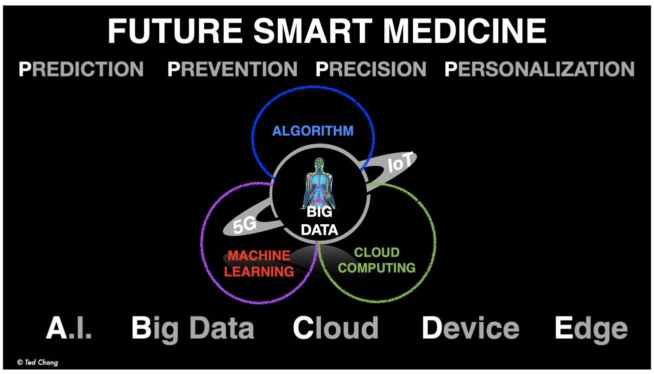

Fig. 2. ABCDE: AI, Big Data, Cloud, Device and Edge

Quanta AIoT Platform

Quanta AIoT platform illustrated in Fig. 3 is developed by the collaboration among MIT Computer Science and Artificial Intelligence Laboratory (CSAIL), Quanta-NYCU Joint AI Center and Quanta Computer. Quanta AIOT Platform is architected for smart applications and services in different domains like Healthcare, Education, Smart City, Agriculture and transportation, depending on the users, use cases and data used [3].

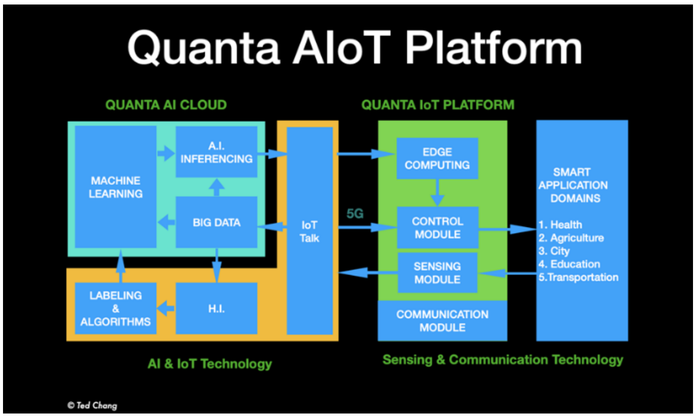

Fig. 3. Quanta AIoT platform

Quanta AIoT Platform includes the Quanta IoT Platform, IoTtalk and Quanta AI Cloud. The Quanta IoT Platform consists of three modules. The Sensing Module connects to different sensors, like ECG, SPO2, blood pressure and thermometer for healthcare. The Control Module connects to actuators to provide feedback control based on the data sensed and the algorithm installed. The Communication Module provides different connectivity and act as a gateway for wireless connected sensors. These modules can connect to AI Medical Cloud either directly or indirectly through IoTtalk. IoTtalk is a system that interfaces both Quanta AI Cloud and IoT Platform for remote IoT monitoring, management, control, calibration and data handling [4][5]. Quanta AI Cloud privates cloud that integrates both advanced server, storage and network switches from

Quanta Computer for Infrastructure as a Service(IaaS) and an optimized platform as a service(PaaS) for the whole pipeline of AI processing, which includes tools for big data analytics, governance, administration, data preparation, labeling, neural network model selection, training, Machine Learning, validation and inferencing.

Quanta AI cloud also supports AI deployment through OTA to IoT for Edge AI computing as illustrated in Fig. 4 for continuous optimization and self-learning.

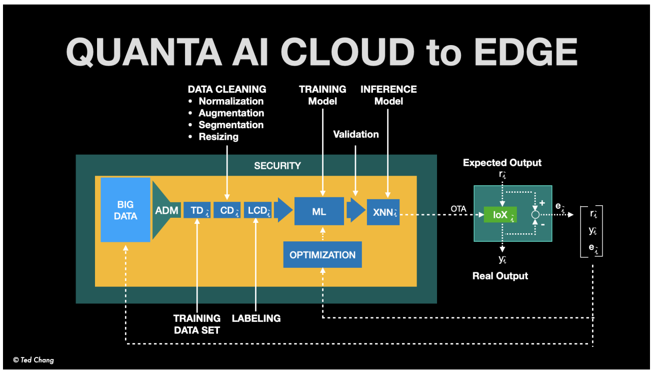

Fig. 4. Quanta AI: from cloud to edge

Quanta AI Medicine Cloud

“QOCA®aim” illustrated in Fig. 5 is a Quanta AI Cloud further tailored for physicians and smart medicine applications. QOCA® aim is designed not only for data engineers but also for data scientists like those physicians with strong domain know-how and with less coding skills. The IaaS is optimized for medical data with PaaS optimized for both machine learning and Digital Twin simulation. The resulting algorithms and neural network models shall be packaged as software applications in the SaaS layer.

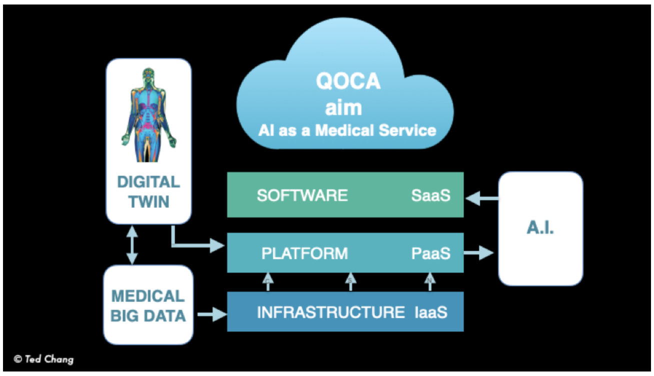

Fig. 5. QOCA® aim: the abstract view

Fig. 6 illustrates a more comprehensive structure of QOCA® aim. The raw medical data contains diversified data of signal, text, images, audio, video, to genetics sequences from Hospital Information System (HIS), EMR, Radiological Information System (RIS), Picture Archiving and Communication System (PACS), Laboratory Information System (LIS) and Pharmacy Information System (PIS) for precision medicine research. Additional work in processing data generated from the machine learning includes labeling data and neural network models shall also be archived as meta data of the projects. These meta data are extremely important to increase the speed and depth of collaborations among researchers using the same data set for AI.

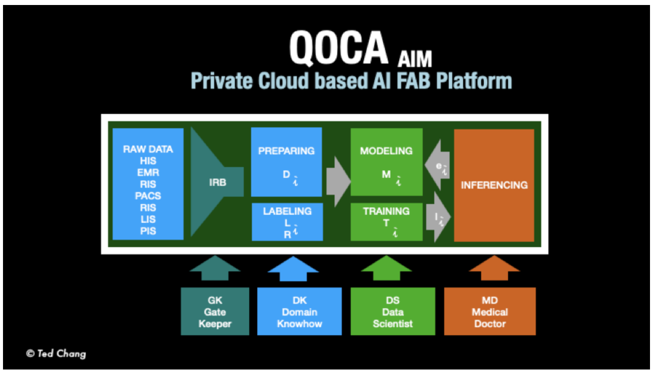

Fig. 6. QOCA® aim: the architecture

CASE I: Quanta Smart Telemedicine

Modern healthcare has paid more attention and resources to telemedicine development. Due to COVID-19, zero-touch healthcare between doctors and patients significantly promoted telemedicine solution [6].

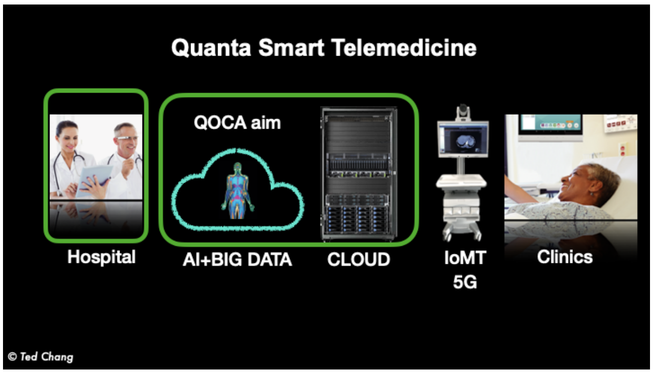

Fig. 7. Smart Telemedicine

Quanta Smart Telemedicine solution, QOCA® atm, is a cloud-based collaboration platform designed for hospitals with different professions to collaborate over the "Virtual Clinic" created on demand over the cloud as depicted in Fig. 7. The virtual clinic room offers real-time visual communications, shared whiteboard and electronic medical record and DICOM images sharing for joint diagnosis and AI inferencing from QOCA® aim. In addition, with the medical inspection systems, like portable X-Ray, mobile ultrasonic and endoscopes, connected as IoMT to the smart telemedicine platform, the system offers remote guided inspection for more precision medicine service. QOCA® atm has been successfully adopted in the major hospitals like Taiwan University Hospital (NTUH) Yunlin branch and Hsin-chu branch to support better quality of medical service in rural areas. The Hsin-Chu case has been published as a successful digital health story in the website of Supporting Emerging Technology Taskforce for APEC Business Advisory Council (ABAC). For more information to see the system at work, please refer to the following website, https://emerging-tech.site/smarter-telemedicine-in-rural-areas-ntuh-hsin-chu-branch/

CASE II : Quanta Smart Telehealth

Quanta Smart Telehealth, QOCA® acc, as illustrated in Fig. 8, aims at leveraging AIoT to tackle the problem of discharged patients, elderly care and chronic disease patients at home or care center. Due to the outbreak of COVID-19 pandemics, the system is further enhanced as a special version QOCA® aqc (Fig. 9) to cover the needs of quarantined patients in the isolated wards or quarantine hospitals. The major difference between CASE I and II are the scale of the patients to be monitored over the cloud and the medical devices used. For QOCA® acc there will be a web-based Case Management Portal(CMP) to support the call center so that one case manager could manage to watch over hundreds of patients at the same time. Moreover, AI and algorithms will be applied to monitor the changes of vital signs measured over time for early warning. The system supports multipoint video conferencing for social care. The connected medical devices designed will be of lower power, light weight with smaller form factor for home users. for more detail of these wearable medical devices, please refer to http://www.qoca.net/. Different versions of QOCA® acc have been widely applied and pilot-run for elderly care in Baycrest Canada, Post-Discharge Cardiac Care and High-Risk Patient Care in NTUH Yunlin branch, and quarantine patient care in Taipei Veterans General Hospital (TVGH) among many others. Some of the successful cases could be found in the ABAC supporting emergent technology website: https://emerging-tech.site/cases/ .

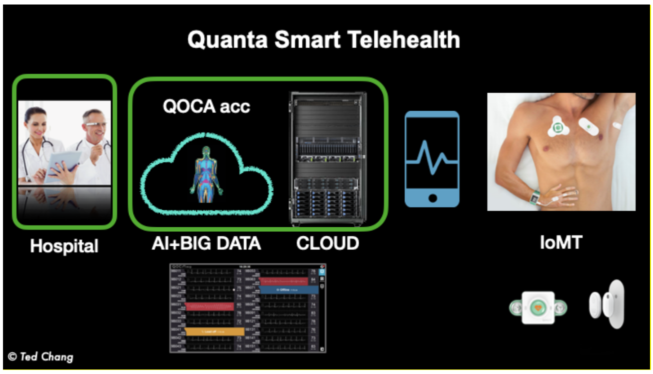

Fig. 8. Quanta Smart Telehealth

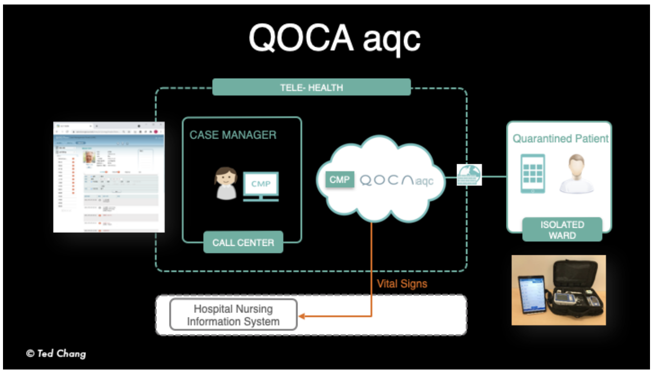

Fig. 9. QOCA® aqc

CASE III : AMBtalk: Quanta Smart Ambulance

An important function of smart ambulance is quick and primary diagnosis at point-of-care. For example, Acute Coronary Syndrome (ACS) emergency events require immediate chest pain identification in the ambulance. Fig. 10 illustrates Quanta Smart Ambulance for accurate and early ACS identification in an ambulance that provides real-time connection to hospital resources. The key to success is the development of the Quanta ecg1201 and AllCheck® [7] IoT devices, which quickly and accurately provide cardiovascular parameter values for early ACS identification. Quanta ecg1201 is a 12-leads portable ECG device with special electrodes patch design to assist non-professionals can place the electrodes at the right positions for signal data taking. The interactions between the diagnosis IoT devices, the emergency medical service center (EMS), the ambulance personnel and the hospital are achieved through the AMBTalk server in the cloud network. The server includes a video server that provides video streaming to be analyzed by QOCA® aim. The signals of the IoT devices in the ambulance are sent to the IoTtalk server. The IoTtalk server then forwards these signals to QOCA® aim for analysis. The resulting decisions are sent to the EMS for action. Right now, AMBtalk is being exercised in Department of Emergency and Critical Care Medicine of Changhua Christian Hospital Taiwan.

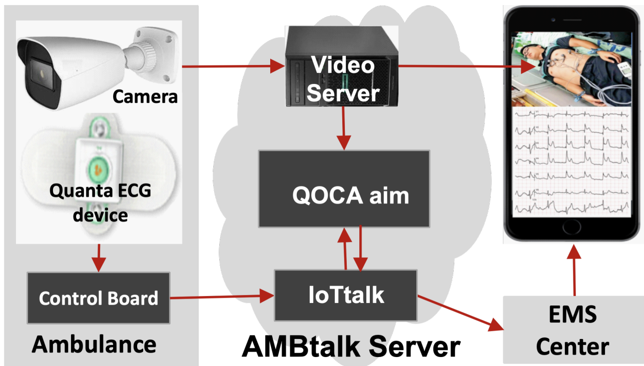

Fig. 10. Smart Ambulance

Conclusions

Quanta QOCA® is a novel end-to-end AIoT cloud platform for both AI and IoT, which addresses the critical healthcare transformation problems under pandemics. QOCA® fully utilizes the data measured by IoT, conducts data preprocessing in Quanta cloud, and then provides valuable healthcare analytics through machine learning or deep learning. We demonstrated three sustainable cases of Quanta healthcare solutions: smart telemedicine, smart telehealth and smart ambulance. These Quanta show cases indicate the AI core value of AIoT for the digital transformation of healthcare and precision medicine for the future.

References

[1] S. Vishnu, S. R. J. Ramson and R. Jegan, "Internet of Medical Things (IoMT) - An overview," *2020 5th International Conference on Devices, Circuits and Systems (ICDCS)*, 2020, pp. 101-104, doi: 10.1109/ICDCS48716.2020.243558.

[2] S. Gaikwad, "Study on Artificial Intelligence in Healthcare," *2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS)*, 2021, pp. 1165-1169, doi: 10.1109/ICACCS51430.2021.9441741.

[3] Y.-B. Lin, T. C.-Y. Chang, "QOCA® and IoTtalk for PPP", *PUBLIC/PRIVATE PARTNERSHIP AWARD Runner Up, World Information and Technology and Service Alliance(WITSA) Global ICT Excellence Award, 2021*

[4] W. -L. Chen *et al.*, "AgriTalk: IoT for Precision Soil Farming of Turmeric Cultivation," in *IEEE Internet of Things Journal*, vol. 6, no. 3, pp. 5209-5223, June 2019, doi: 10.1109/JIOT.2019.2899128.

[5] Y. Lin, Y. Lin, C. Huang, C. Chih and P. Lin, "IoTtalk: A Management Platform for Reconfigurable Sensor Devices," in *IEEE Internet of Things Journal*, vol. 4, no. 5, pp. 1552-1562, Oct. 2017, doi: 10.1109/JIOT.2017.2682100.

[6] A. Romanovs, E. Sultanovs, E. Buss, Y. Merkuryev and G. Majore, "Challenges and Solutions for Resilient Telemedicine Services," *2020 IEEE 8th Workshop on Advances in Information, Electronic and Electrical Engineering (AIEEE)*, 2021, pp. 1-7, doi: 10.1109/AIEEE51419.2021.9435776.

[7]W.-L. Chen, Y.-B. Lin, T. C.-Y. Chang, Y.-R. Lin, AMBtalk: A Cardiovascular IoT Device for Ambulance Applications. Sensors 2021, 21, 2781. https://doi.org/10.3390/s21082781