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IOMT: A New Research Paradigm in IOT

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ABSTRACT: Multimedia acquisition and communication by current IoT computing techniques is not realizable, because they mainly consider the former's scalar data-inducing applications which demand a simple processing capability and a lower data rate at the sensing device, and do not solve the challenges posed by multimedia data. Multimedia data over IoT system essentially requires a novel research on its computing techniques and system design that involve heterogeneity of multimedia devices, multimedia sensing, multimedia-aware cloud, multimedia data analytics/processing, and other issues to make multimedia IoT applications realizable. This paper presents IOMT-Internet Of Multimedia Things architecture along with its challenging issues & research directions.

KEYWORDS: IOT, IOMT, Multimedia Communication.

I. INTRODUCTION

The Internet of things (IOT) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators which enable these things to connect and exchange data. It creates opportunities for more direct integration of the physical world into computer based systems, resulting in efficiency improvement, economic benefits and reduces human intervention. The Internet of things (IoT) enables a number of physical devices around us to interact and cooperate with each other, and thus has a great potential to cover almost every industry and application. In essence, IoT system is expected to support a wide array of IoT applications where the devices produce various types of Internet traffic from conventional periodic scalar data such as light, temperature, humidity, etc. to bulky multimedia content such as audio, video, image, etc. The wide ranges of applications of IOT are represented in Figure 1 below.

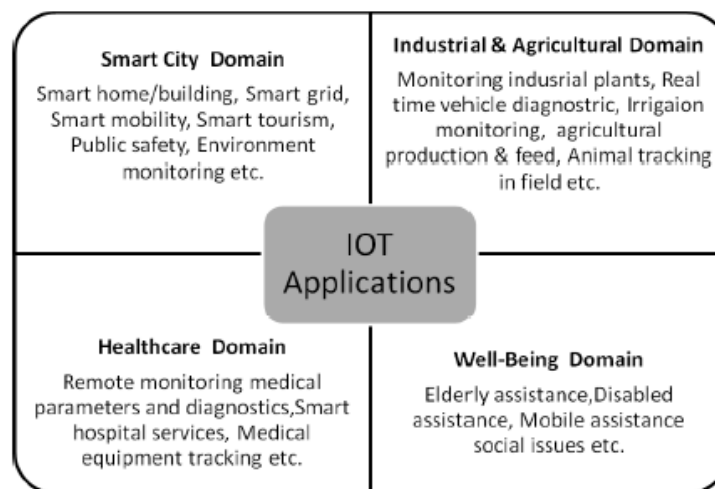


Figure1: IOT Applications

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However, the multimedia acquisition and communication by current IoT computing techniques is not realizable, because they mainly consider the former's scalar data-inducing applications which demand a simple processing capability and a lower data rate at the sensing device, and do not solve the challenges posed by multimedia data. In this regard, the production/delivery of multimedia data over IoT system essentially requires a novel research on its computing techniques and system design that involve heterogeneity of multimedia devices, multimedia sensing, multimedia-aware cloud, multimedia data analytics/processing, and other issues to make multimedia IoT applications realizable. This paper presents a research direction for multimedia communication over IOT. Second section of the paper explains IOMT architecture along with open issues in each stage. Third section explains various applications & user cases of IOMT. Fourth section explains research directions in IOMT & finally fifth section do conclusion.

II. IOMT ARCHITECTURE

IOMT (Internet of Multimedia Thing) system architecture divided into four distinct stages; (i) multimedia sensing, (ii) reporting and addressability, (iii) multimedia-aware cloud, and (iv) multi-agent systems. This architecture is shown in Figure 2 below. Firstly, the multimedia data acquisition and encoding methodologies are discussed. Specifically, the operation of multimedia sensing devices and their characteristics are analysed. Secondly, after the data acquisition process is completed, the next step is to report the multimedia content to the cloud by incorporating efficient communication and addressing techniques. Subsequently, the multimedia content is stored, processed and disseminated as per end-user demand at the cloud. Lastly, the computational and post-processing tasks may be carried out at the cloud according to the application/service requirements articulated by multi-agent systems. In each stage of IOMT various existing technologies of IOT & multimedia communication are available. But they fully not satisfy all requirement of multimedia communication over IOT. All these stages are explained in detail in following paragraphs-

i) Multimedia sensing in IOMT

IOMT multimedia devices are expected to be low-cost and tiny, possessing limited memory resources. Embedding low level local intelligence on small multimedia devices can enable enormous application in automation and robust system operation. The processing power for IOMT multimedia devices is curbed, therefore the operation of existing multimedia encoding schemes on these devices is infeasible. Consequently, computationally less complex encoding techniques are required, in this matter compressive sensing based encoding techniques seem like a potential technology. It is a tradeoff between the level of compression achieved and the bandwidth requirement. An interesting issue is to minimizing the processing overhead which is directly proportional to energy consumption for a given set of bandwidth and compression requirements. Efficient energy harvesting procedures need to be devised to energize sensors and prolong the network lifetime.

ii) Reporting and addressability

One of the most critical challenges for the IoT communication stack to support multimedia communication is its higher data rate requirement. However, energy efficiency along with QoS support by Wi-Fi that is devisable to ZigBee is an open challenge. Routing protocol is highly flexible and adaptive. However, proposed routing metrics for route selection are based on link quality, energy, or path length. For IOMT new routing metrics should be considered that may energy efficiently route the multimedia traffic for specific QoS bounds and requirements. Real time streaming protocols are required to initialize sessions and retrieve multimedia content from servers, considering the processing capability and the Internet bandwidth of the user device. In IOMT system, the acquired multimedia video needs to be encoded using low-complexity encoders to alleviate the processing and energy consumption overheads from the multimedia sensing devices. Therein, high compression can be achieved but then complexity of the decoder at the end device is radically increases. Therefore, the trade-off between the compression and complexity at the sensing device and the complexity of the decoder needs to be investigated.

iii) Multimedia-aware cloud

It should provide following services-Enable service provisioning and render distinct multimedia services and applications. Provide the abstraction of heterogeneous multimedia devices to the multi-agent system in order to

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compose distinct multimedia applications/services. Provide context information based management of network resources, e.g. efficient bandwidth utilization and computational capacity. Provide user personalization feature to fulfill end-user application requirements and improved user experience. Object naming services to uniquely identify and address massive number of devices. This service should be scalable, persistent, and reliable. Owing to the dynamic change in access and authorization roles at run-time, which are in turn being employed on variable and dynamic multimedia data streams, the existing customary solutions lack the rigorous requirements posed by multimedia data retrieval in real-time and in a flexible manner.

iv) Multi-agent systems

Multimedia based services require critical composition and customization as per the user preferences, device capabilities, QoS, and QoE. The context awareness at multiple levels including user-context, device-context, cloud resource-context, network-context and service-context, can be categorized. Another open issue for multi-agent systems is to design self-service provisioning, on demand rental services, quantitative and qualitative services multimedia content based applications. Multi-agents should be able to compare and extract meaningful information from different types of multimedia content and apply different strategies to satisfy certain application specific objective functions. Multimedia adaptation mechanisms need to be devised which can adapt to the distinct user device and network characteristics.

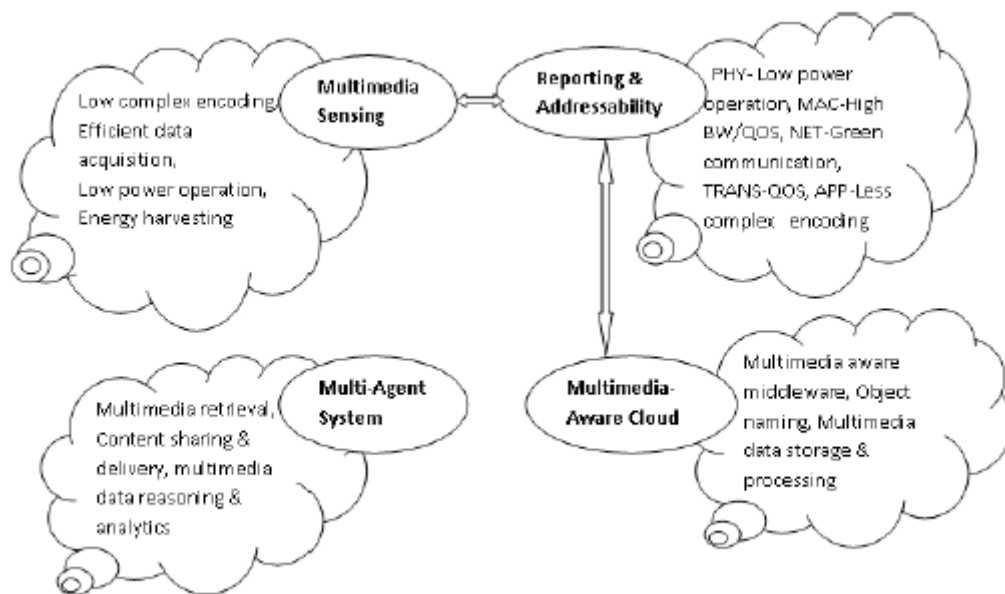


Figure 2: IOMT Architecture

III. IOMT APPLICATIONS AND USER CASES

Heterogeneity of multimedia sensors, ubiquitous connectivity, QoS and QoE requirements, cloud based analysis and autonomous reaction approaches constitute the key characteristics of IOMT. Leveraging cloud based resources to process video analytics; cameras can be the most intelligent IoT sensors. IOMT-enabled state of the art analytics and video surveillance systems can be transformed from a cost centre for businesses to actually driving operational savings and delivering real return on investments besides providing superior security control. Deployment of cameras in an IoT setup would fulfill its full potential when accompanied with the ability to automatically glean actionable information from the

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visual streams, which could then be exchanged with other things when appropriate, eventually leading to some action taken by the things autonomously with rare human involvement. The bottom line is keeping human involvement in the entire process down to a viable minimum. Since, the multimedia content especially video data is extremely rich in information. Thus, advanced video analytics enables extraction of various kinds of information from a single video stream which would otherwise require a plurality of sensors. Object and motion detection, facial recognition, number plate identification, situational and acoustic awareness, video search and forensic analysis, counting applications, intrusion and virtual line/gate crossing detection, theft detection are some of the features that can be extracted from video streams. A few possible use-cases of IoMT are as follows –

i) Ecosystem of everyday things

A scenario of IoT with ‘multimedia things’ in everyday route information to the multimedia-aware cloud for traffic information is one of the most useful application of IOMT. With the help of multiple video sensors along the route, the multi-agent system analyses the traffic and route statistics. It is informed that it has been raining all night and one of the main roads along the route is inundated causing a traffic jam. The navigation system recalculates the travelling time along a different route and informs the scheduler that you should leave 15 min earlier than usual. The scheduler thus delays the alarm by 5 min and signals the coffee maker to turn on 5 min later as well. It also signals the car to start in 10 min in order to warm up the engine beforehand in the cold or damp weather.

ii) Behavioural interpretation systems

It can be implemented by streaming video content to a control centre where a person is required to monitor any unusual behaviour. Conversely, in smart multimedia networks the behavioural analytics can be done at smart camera nodes to interpret the event and appropriate reactive approaches can be executed such as reporting to a public safety department, triggering alarms to notify the responsible personnel, calling for medical or other types of assistance.

iii) Telemedicine

IoMT paradigm can enhance the applicability of telemedicine and bring valuable advancement in the tele-healthcare technologies especially for rural areas. The technological solutions envisioned within IoMT can be specifically more beneficial for under-developed countries. As a case study, real-time monitoring of patients living in a remote town is realizable using smart multimedia devices. Doctors can be provided with an early and easy access to remote patient’s medical history stored at the multimedia-aware cloud. On the other hand, patients can get the access to specialized doctors of particular treatments in a rapid and cost effective manner. Sensing devices can be employed to detect pollution level or a contagious disease by retrieving information from a remote environment or habitat. Sensors technologies which have already enabled the remote monitoring of patients can be complimented by multimedia camera nodes to deliver a real-time map of patients’ everyday routine and proactive feedback and reminders can be sent. In case of any indescribable health problem, a disable or elderly patients can be kept under eye and accordingly be advised to take necessary precautionary measures. Similarly, in another scenario, the patients under observation in a hospital can be examined by doctors from a remote location via multimedia devices. Data collected from these patients can enable doctors to identify any indication of upcoming severe event so that necessary action may be taken pre-determinedly. It also facilitates the process of decision making. A patient with higher risk should be given more priority while scheduling a treatment-list by the doctors.

iv) Smart societal interaction

The ideas of smart communities and social interactions, a hot topic in current research, can be given a new dimension in the presence of IoMT multimedia devices. The societal and communal impact of the multimedia devices is huge and the increase in offered functionalities enabled by multimedia sensor devices is reshaping people-to-people interaction, people-to-device interaction and inter-devices interaction. A possible scenario of IoMT in the context of social community is interaction of multimedia devices that capture two persons who are travelling in a close near-by location and may be interested in having a lunch at some fast food place. Smart multimedia devices, while interacting with social media and networking websites, intelligently learn that these two people are friends and thus inform them on their smart phones that they are in near-by location and potentially hangout with each other. Furthermore, multimedia multi-agents

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can collect and integrate social media information about these two persons and suggest them about some social event, near-by shopping mall, a cinema theatre or any other activities of their interest.

v) Smart business management and marketing-

In business management and marketing, the decision making can be made smarter and timely with the help of modern video analysis techniques. When events with operational implications occur, the businesses can be alerted. These alerts can be delivered on smart phones of the relevant personnel or to the operation center making timely reactions possible. For instance, consider a retailer's place where customers are entertained based on their profile to offer intelligent services. Customers can be identified by their cars' registration number with the help of smart cameras. When a loyal customer with some disability arrives in the parking lot, the nearest staff member can be located and an alert can be dispatched to her smart phone so that she can welcome and assist the customer. Similarly, some other relevant implications are as follows:

(1) Service personnel can be instantly alerted when queues are formed at the checkout, (2) customer statistics can be gathered and their behaviours can be gauged, (3) the number of customers can be counted, average amounts of time spent looking at a certain product can be understood and traffic flow maps within a store can be generated. These patterns can be used to determine the most sought out products and efficacy of product displays. Over time this information can be collected for more informed resource allocation, product displays and promotions, (4) crowd fluctuations on daily, weekly and monthly basis can be monitored and staff duties can accordingly be assigned. Discrepancies can therefore be automatically identified and promptly reported.

vi) Automated public security

In the IoMT world video streams can enable the public safety. A shot has been fired by a person in a crowded street. Audio analysis of the sound by the cameras in the vicinity of the shooter would enable the detection of gunshots. To provide rapid medical assistance to the victim, the smart multimedia devices deployed in the vicinity can detect the happening of a unusual event. The incident information is reported to a nearby hospital which in turn dispatches the ambulance right away. The doctors are facilitated to visualize the real-time video streaming from the incident, hence improving the medical response time. Simultaneously, the shooter would be identified amongst the crowd and his motion would be predicted. Based on the direction of motion of the shooter, camera controller will inform the next cameras in the path of the shooter to adjust their resolution and orientation. The controller will contact the nearest law enforcement patrol and continuously update the location of the shooter on the patrol's navigation. Meanwhile, the controller will transmit the facial information to identity database, police and medical databases so that his identification, past criminal record and medical history can be checked. The navigation on the patrol will communicate with the traffic signals to control the flow of traffic to avoid any interruptions in their movement.

There are various open issues in each stage of this architecture. In this context, there is a research on multimedia-aware IoT computing techniques and system design especially considering the requirements/challenges posed by bulky multimedia IoT data communication. It addresses various types of research activities such as the security issues, design, development, analysis, standardization, and application/service models.

IV. AREA OF RESEARCH IN IOMT

After analyzing IOMT architecture along with existing techniques & applications various research gaps for multimedia communication over IOT is obtained. From that area of research in IOMT can be found out. Area of research in IOMT consists of-

- a) Multimedia-aware IoT system architecture
- b) Multimedia-aware IoT communication stack and protocol
- c) Multimedia streaming and encoding for IoT system
- d) QoS, QoE, mobility, security technique for multimedia-aware IoT system
- e) Multimedia-support embedded IoT device and forensics issues
- f) Cloud computing and data analytics for multimedia-aware IoT system

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- g)Multimedia-aware IoT system modeling and simulation techniques
- h)Multimedia-aware and various IoT service platform security
- i)Prototypes, test-beds, field trials for multimedia-aware IoT system
- J)Standardization and open source development for multimedia-aware IoT system

V. CONCLUSION

Internet of Multimedia Things represents a specialized subset of Internet of Things, enabling the integration and cooperation among heterogeneous multimedia devices with distinct sensing, computational, and communication capabilities and resources. A multimedia-aware cloud combined with the multi-agent systems can help design prodigious multimedia services and applications. As compared to IoT, the realization of IoMT rather has some additional challenges and stringent requirements. The current task group activities for IoT do not mandate the features of multimedia things, thus leaving a gap to benefit from IoMT paradigm. This survey presents the vision of IoMT, highlight its unique characteristics in contrast to IoT, and identify the major challenges and requirements in order to realize the IoMT. Considering these technical specifications of IoMT, the feasibility of the already proposed communication Stack for IoT is discussed. In addition, the multimedia content processing at resource constraint multimedia devices in IoMT is analysed. The solutions to the processing/computational issues are provided by introducing the notion of multimedia-aware cloud combined with multi-agent systems for IoMT architecture. Lastly, some applications and use-cases of IoMT are discussed to further clarify and help make understand the research community about the true potential of IoMT. Thus this paper introduces IoMT paradigm and architecture to identify its issues and obligations. We believe that substantial standardization efforts are needed to address the open issues in order to realize true potential of IoMT.

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