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# Internet of Musical Things: A Survey

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***Abstract***— IoMUT refers to the inter-networking of physical musical objects which are used in the production and/or reception of musical content. A network infrastructure that interconnects various smart musical instruments or devices and permits multidirectional communication between them, both locally and remotely is designed in IoMUT.
The IoMUT system interconnects performers and audiences and enables performer-performer and audience-performers interactions. The paper presents a survey on this novel concept of IoMUT.

***Keywords***—IoT, IoMUT, Smart Devices, Musical Things

## I. INTRODUCTION

"Internet-of-Things" or IoT is a keyword which covers several aspects related to the development of the Internet into physical reality. Internet of Things is an emerging topic of technical, social, and economic significance [1]. In the recent years, there has been a considerable increase in the usage of smart devices and appliances in our daily lives. The wireless sensor networks (WSNs) are networks of small sensors and actuator nodes that can be embedded in any physical object and controlled. Till date, IoT has been extensively used in smart cities, consumer electronics, education, defense, geospatial, industrial and healthcare domains [2,3]. On the other hand, unlike other domains, the application of IoT concept has not found a significant attention in musical field.
In this paper we would like to discuss the concept of Internet of Musical Things (IoMUT) starting with exploring the Existing Technologies in section 2, followed by concept of IoMUT in section 3, Inferences in section 4, Current Challenges in section 5 and Future Scope with conclusion in section 6.

## II. EXISTING TECHNOLOGIES

In this section, the existing technologies used for implementation of IoMUT are mentioned in brief.

### *A. IoT Technologies*

Internet of Things is an emerging topic which has gained lot of significance in almost all the fields. Consumer products, automobiles, industrial and utility components, sensors, and other everyday objects are being interconnected through Internet and equipped with powerful data analytic capabilities and embedded sensing and actuation capabilities.

The concept of IoT, was proposed by Ashton [1]. IoT, is acquiring the Internet by integrating objects or devices through embedded systems and is making it a highly distributed network of communication with humans and devices [2,3]. Broad research in Wireless sensors networks (WSNs) design has led to the design of novel communication protocols which support low data rate and low power consumption.

Unfortunately, many of these protocols are not favorable for the inter-networking of musical instruments. Because, the interconnection of musical instruments sets requirements in terms of end-to-end latency to transmit and receive messages which are very stringent.

This is leading to the development of a unique paradigm – "Tactile Internet" [4] and millimeter Waves (mmWaves) communications [5,6]. Tactile Internet refers to an Internet network where the communication delay between a transmitter and a receiver would be so low that even information associated to human touch, vision, and audition could be transmitted back and forth in real-time, making remote interaction experiences, virtual or human, effective, high-quality and realistic.

This novel area focuses aides in designing communication networks, with ultra-low latency and delays of the order of few milliseconds. The important facets of the Tactile Internet vision are, reliability and low latency. Another emerging wireless communication technology is mmWaves. It uses frequencies between 10 - 300 GHz and offers data rates in giga bits/seconds. These frequencies enable design of small antennas that can be easily embedded in musical instruments [7].

 

### B. *Networked Music Performance Systems*

Networked music performance (NMP) systems were proposed to enable collaborative music creation over a computer network. A notable example is the ReacTable [8], which allows multiple performers to simultaneously interact with objects either placed on the same table or on several networked tables in geographically remote locations.

### C. *Smart Instruments*

Recently, a new class of musical instruments - the Smart Instruments has been proposed [9]. Smart Instruments are embedded with computational intelligence, a sound processing- synthesis engine, bi-directional wireless connectivity, a sound system, and a system for feedback to the player. Using IoT concepts, the Smart Instruments can be made capable of communicating with each other which will give rise to a unique way of collaborating different types of musical instruments which will in turn, give a different experience to audience.

MIND Music Labs has recently developed the Sensus Smart Guitar [9] which is a modified version of conventional electroacoustic guitar that is enabled with IoT technologies. It includes several sensors embedded in various parts of the instrument, which are used to modulate and produce various digital sound effects. This Sensus Smart Guitar is equipped with bidirectional wireless connectivity, which enables interaction with variety of smart devices and vice versa.

### D. *Virtual Reality, Augmented Reality, and 360 Videos*

The last two decades have seen an increase of both academic and industrial research in the fields of virtual reality (VR) and augmented reality (AR) for musical applications. Several virtual musical instruments have been developed, while musical instruments augmented with sensors, such as the Sensus Smart Guitar, have been used to interactively control virtual reality scenarios displayed on head-mounted-displays (HMD) [7]. AR has been used to enhance performance stages for augmented concert experiences, as well as for participatory performances applications. Techniques such as the augmented stage [7], Reflets, augmented groove, VR headsets, FOVE's Eye Play The Piano project for visually impaired are used for conducting multimedia musical performance.

## III. THE INTERNET OF MUSICAL THINGS

The Internet of Musical Things (IoMUT) refers to the networking of musical objects required for production of musical content or to experience the music. A Musical Thing can be Smart Instrument, a Smart Wearable, or any other smart device used to control and generate musical content. IoMUT is a unique concept which has the capability to enable wireless communication between Musical Things Figure 1 below depicts the general structure of IoMUT.

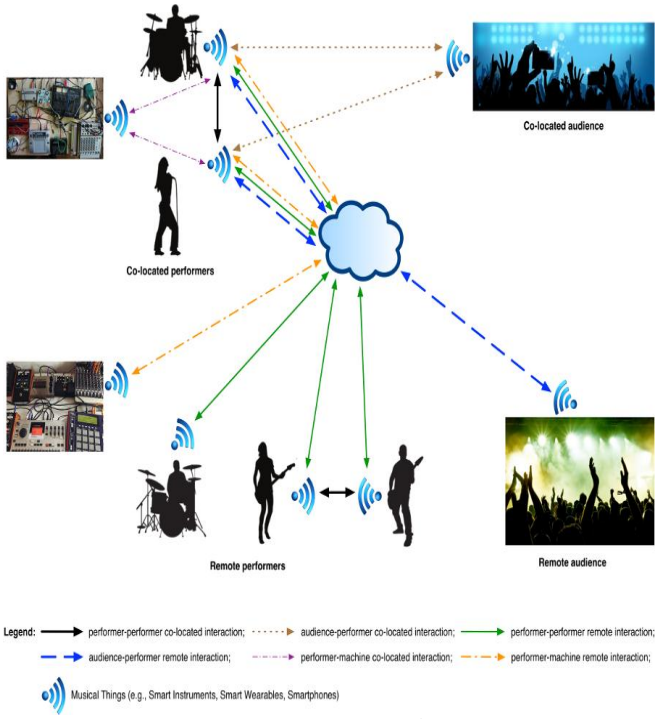


Figure 1 General Structure of IoMUT

IoMUT consists of music-specific hardware and software (such as sensors, actuators, devices, networks, protocols, APIs, platforms, clouds, services) with low latency, high reliability, high quality, and synchronization between connected devices. Such an infrastructure enables the performers to connect to their co-performers and audience as well. Figure 2 shows a conceptual diagram of the IoMUT system.

As it can be seen in Figure 2, the interactions between the performers and audience is carried out through various Musical Things. Interactions can take place (blue arrows), when the artists are in same physical space (e.g., concert hall), or different. They are connected by a network (black arrows). Co-located interactions are based on point to point communications which take place between a Musical Thing of the performers and a Musical Thing present with an audience member (blue dashed arrows). Also, multiple performers can interconnect their Musical Things with one or more Musical Things and vice versa (blue solid line arrow. Remote interactions can occur not only between audience and performers locally (solid black arrows), as well as remotely (black dashed arrows). The communication between Musical Things is achieved through APIs (application programming interfaces, indicated in Figure 2 with small red rectangles).

 

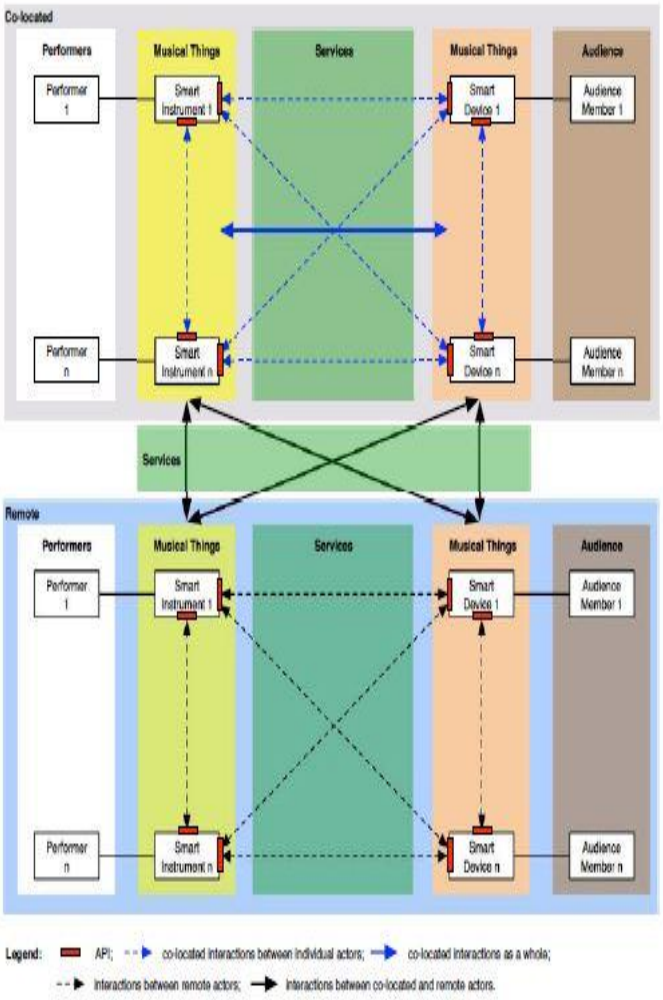


Figure 2 IoMUT System

## IV. INFERENCES

Through IoMUT it is possible to enjoy live performance of art and music without physical presence at the place of performance. This novel technology has the potential to revolutionize the way to experience, compose, and learn music. In particular, IoMUT has the potential to make NMP more open. This novel method addresses the fundamental difficulties of latest methods, which hamper expressive interactions between performers and audience. One of the noteworthy result of IoMUT is the haptic feedback smart wearable with which, the audience can "feel" the vibrato of a smart violin or the rhythm of a smart drum. By combining smart musical things with VR/AR applications it is possible to enable the aspirants to learn new forms of music and it will aid the composers in composing. Also, it will enhance the experience of the audience.

## V. CURRENT CHALLENGES

The most specific technological challenges of IoMUT are the requirements of very short latency, high reliability, high audio/multimodal content quality, and synchronization to be ensured for musical communication. This points towards the creation of a technological infrastructure that is capable of transmitting multimodal content, and in particular audio, from one musician to another/others not only in hi-fi quality, but also with a negligible amount of latency, which enable performers to play in synchronous ways. Current IoT scientific methods and technologies do not satisfy these tight constraints needed for the real-time transmission of audio/multimodal content both at short and at large distances [7].

Another important challenge of IoMUT is in regards with the interconnection of different types of devices. Ad-hoc protocols and interchange formats for exchanging information has to be common to all the Musical Things and APIs have to be specifically designed for IoMUT applications.

IoMUT poses a need for new analytical tools and algorithms to process large amounts of music-related data. Also, issues related to security and privacy of information should also be addressed, especially if such system was to be deployed for the masses.

## VI. CONCLUSION AND FUTURE SCOPE

IoMUT relates to wireless networking of Musical Things. Interconnection and interaction between performers, audiences, and their smart devices through wireless technology is the main objective of IoMUT. IoMUT transforms the traditional performer-audience chain into a musical network interconnecting performers and audiences even if both of them are at remote locations. Novel technologies such as Smart Musical Things, VR, AR, NMPs enhance the quality of experience for both performers and audience and also they have paved many new ways for improving the quality of networking. The IoMUT on the other hand poses some challenges that will be faced in upcoming years by both researchers. IoMUT is an emerging area in which multi-faceted research can take place.

## REFERENCES

[1] The Internet of Things: an Overview, Internet society, October 2015.

[2] Santosh S. Kulkarni, Sanjeev G. Kulkarni, Vani P. Datar, "*Current Trends in Internet of Things: A Survey*", International Journal of Computer Sciences and Engineering, Vol.6, Issue.6, pp.1223-1226, 2018.

[3] Swaroopa P T, Chaitra H K "*International Journal of Computer Sciences and Engineering*" Vol.-4, Special Issue-3, May-2016, E-ISSN: 2347-2693.

 

[4] G. P. Fettweis, "*The Tactile Internet: applications and challenges*," IEEE Vehicular Technology Magazine, vol. 9, no. 1, pp. 64–70, 2014.
[5] H. Shokri-Ghadikolaei, C. Fischione, G. Fodor, P. Popovski, and M. Zorzi, "*Millimeter wave cellular networks: A MAC layer perspective*," IEEE Transactions on Communications, vol. 63, no. 10, pp. 3437– 3458, 2015.
[6] H. Shokri-Ghadikolaei, C. Fischione, P. Popovski, and M. Zorzi, "*Design aspects of short-range millimeterwave networks: A MAC layer perspective*," IEEE Network, vol. 30, no. 3, pp. 88–96, 2016.
[7] Luca Turchet, Carlo Fischione, Mathieu Barthet, "*Towards The Internet Of Musical Things*", Proceedings of the 14th Sound and Music Computing Conference, July 5-8, Espoo, Finland
[8] S. Jord`a, G. Geiger, M. Alonso, and M. Kaltenbrunner, "*The reactable: exploring the synergy between live music performance and tabletop tangible interfaces*," in Proceedings of the 1st international conference on Tangible and embedded interaction, 2007, pp. 139–146.
[9] L. Turchet, A. McPherson, and C. Fischione, "*Smart Instruments: Towards an Ecosystem of Interoperable Devices Connecting Performers and Audiences*," in Proceedings of the Sound and Music Computing Conference, 2016, pp. 498–505.

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