5G and IoT : The Emerging technologies...

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5G and IoT plays are emerging technologies with huge traction from academia as well as industry. Wireless communication devices have exploded in numbers in the last two decades. Fifth-generation (5G) communication systems are envisioned to achieve a high data rate, provide enhanced coverage, enable higher spectral efficiency, achieve high energy efficiency, and ensure a long lifetime of all battery-operated nodes. In many situations, the ubiquitous deployment of wireless devices is hampered by battery limitations. Energy harvesting (EH) is a viable solution to this problem. Although it is possible to harvest energy from sunlight, vibration, and other natural sources, it is radio-frequency EH that is the most convenient option in many wireless applications. It was suggested that the same received signal can be used for both EH and information processing.

As practical EH circuitry is not capable of harvesting energy and processing information from the same signal, time-switching (TS) and power-splitting (PS) protocols were proposed for cooperative networks with an EH relay. Due to fading, the amount of energy harvested varies widely, thereby degrading the average performance of links with EH nodes. We suggest a framework where a supplementary battery augments energy harvested in the supercapacitor. Several new optimization problems arise. We show how the use of a small amount of battery energy can significantly improve the performance of links with EH users. We demonstrate that careful optimization of the EH parameter can significantly enhance throughput. For networks with a constant throughput requirement, we show how the amount of battery energy drawn and the EH parameter need to be carefully optimized as shown in Figure 1a. We show how to channel knowledge can lead to a significant saving of battery energy. We show how choosing the EH parameter based on channel knowledge can lead to higher throughput. We demonstrate that the use of channel knowledge to determine energy drawn from the battery can lead to significant energy savings as shown in Figure 1b. The insights drawn as well as the optimizations performed are of significant importance to system designers.

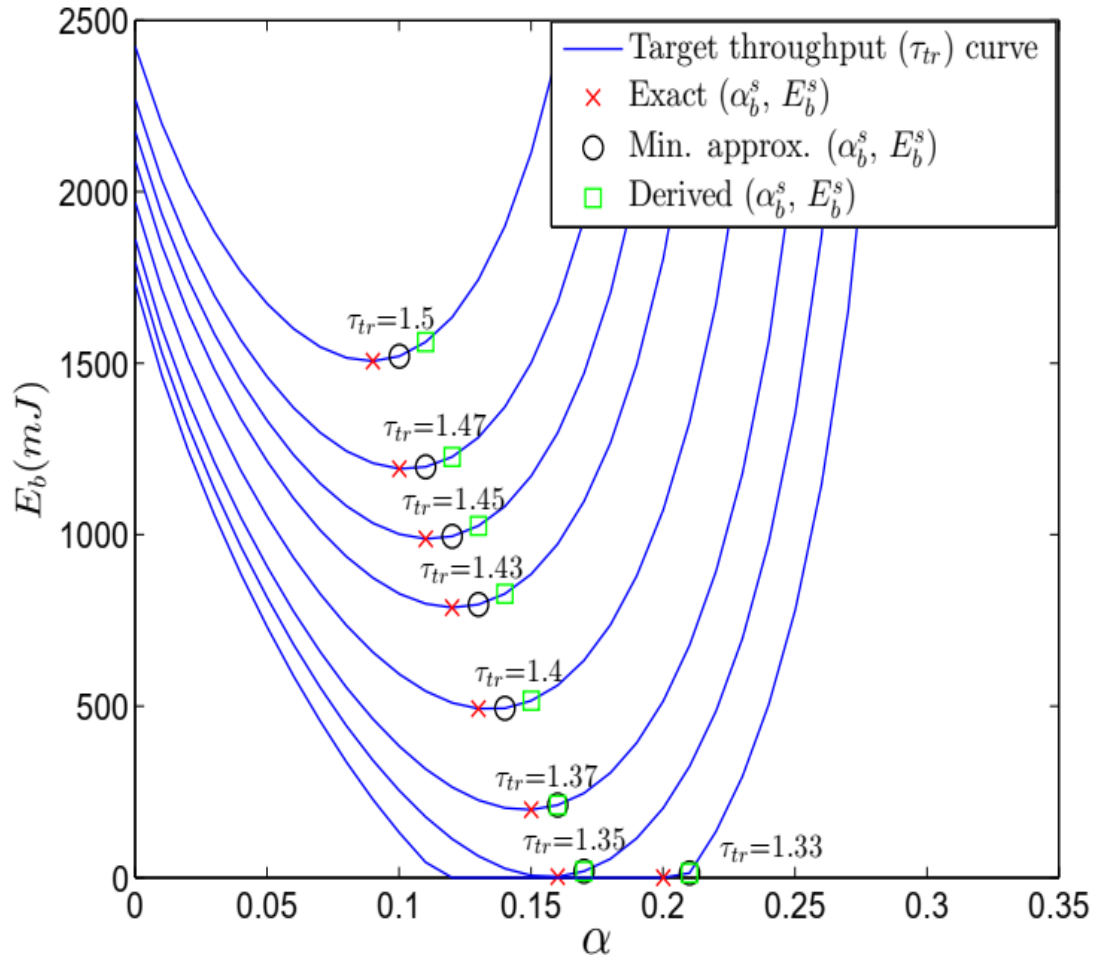

Fig. 9a Energy required vs. TSR parameter for target throughput requirement

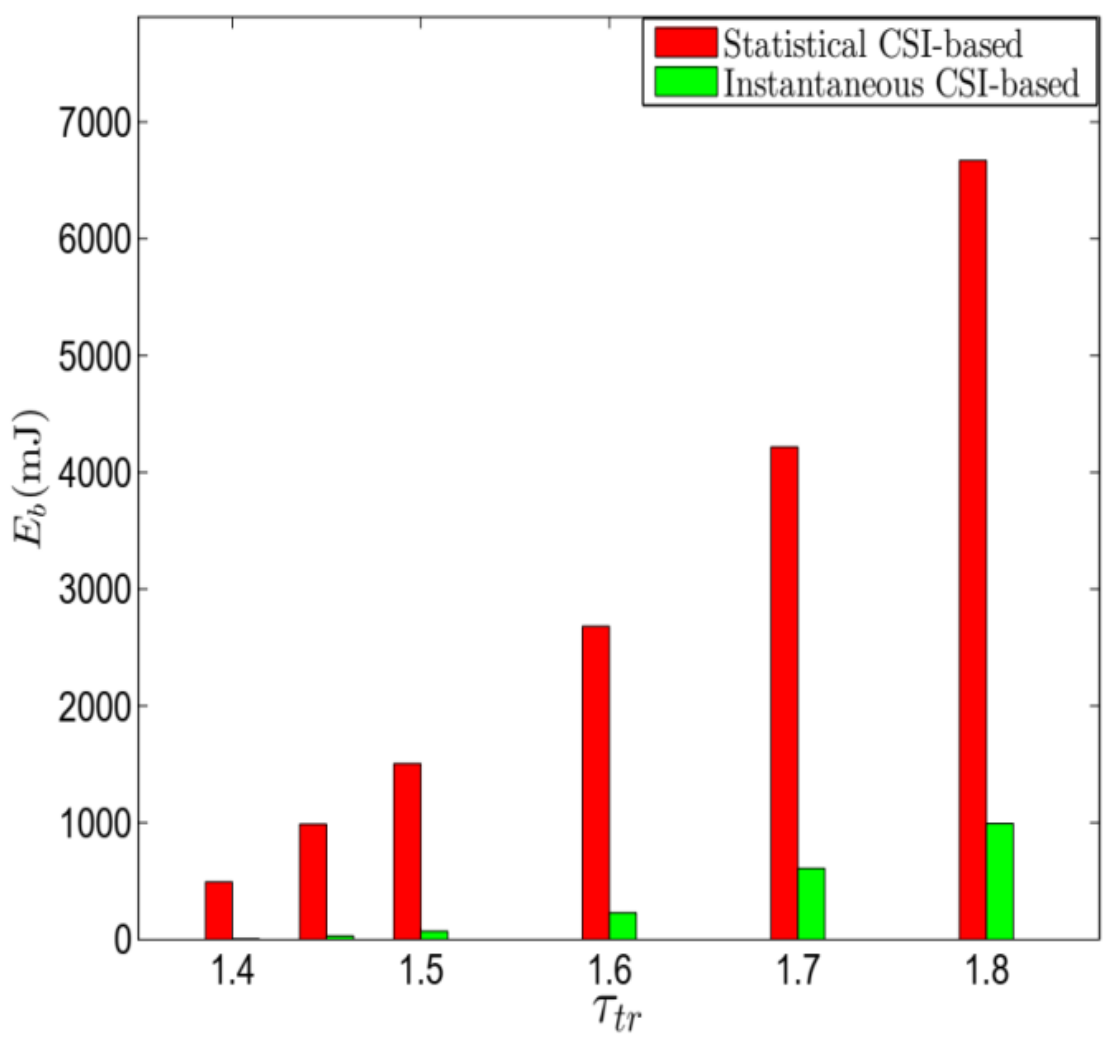

Fig. 9b Energy required vs. target throughput for statistical and instantaneous channel knowledge

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Internet-of-things (IoT) aims to make the Internet ubiquitous and pervasive and has the potential to affect many aspects of users' quality of life. The networked heterogeneous devices connected in an IoT structure are typically equipped with sensors, controlling processors, wireless transceivers, and an energy source (e.g., a battery) to monitor their environment and send/receive data. Applications envisioned for IoT span a wide range of fields including home automation, healthcare, surveillance, transportation, smart environments, and many more. One of the dominant barriers to implementing such a grandiose scheme is supplying adequate energy to operate the network in a self-sufficient manner without compromising the quality of service (QoS). Therefore, it is imperative to improve the energy efficiency and longevity of devices in IoT. The IoT-based precision agriculture system is developed by our team at IIT Jammu on a pilot basis. It is a solar-powered energy harvesting-based IoT system for smart vegetation scenarios. The project includes the design, testing, and deployment of smart monitoring using multihop communication protocol among the devices.

The implementation procedures were shown in Fig. 10. The implementation consists of (i) Prototype design (ii) Field deployment (iii) Monitoring and control from a remote location. The prototype module is initially designed in our lab using Raspberry Pi with sensors of Humidity, temperature, moisture, etc. After initial trials, the prototype is deployed in the field along with energy harvesting recharging batteries. The sensors collect the data and upload it to the IoT cloud using internet connectivity. The uploaded data can be monitored from a remote central control room and mobile app as shown in Figure. Based on received data control action is implemented from a remote location for smart irrigation.

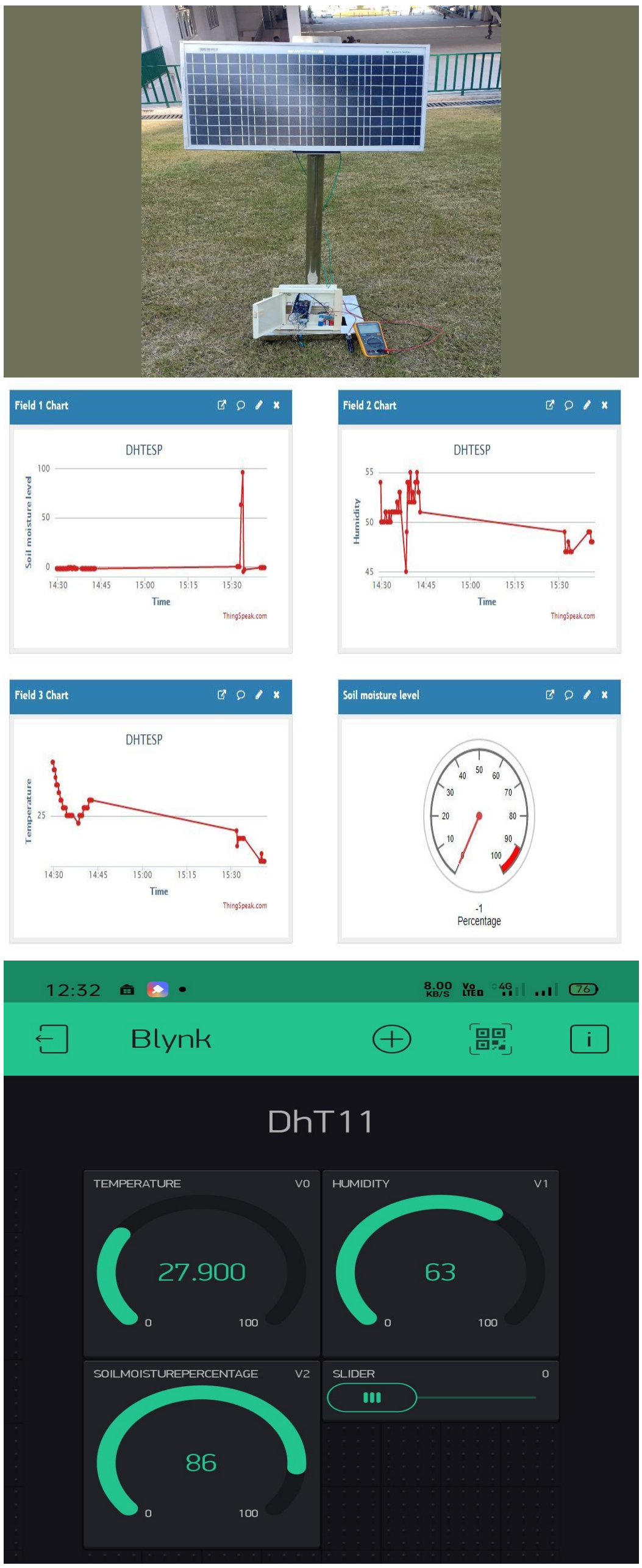

Fig. 10 Precision agriculture using IoT technology PC: Atul Banotra and Shashi Bhushan

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Fig. 11 HAM radio setup with VK Arya team

I am currently working as an assistant professor at IIT Jammu since June 2019. I am alumni of 2010-12 M. Tech. (Communication and signal processing, EE) batch. After IIT Hyderabad, I have completed my PhD from IIT Delhi between 2013-18. I worked as an assistant processor under TEQIP-III between Jan-Aug 2019 and in IIIT Dharwad Aug 2019-May 2020.

After clearing GATE, I have visited some of the institutes for M. Tech. admission. The location and faculty interaction at my visit are the deciding factors for my admission to IIT Hyderabad. Wireless sensor networks are the most enjoyed subject as I have been involved in PCB board development and location transmission system with embedded boards. On the other part, Pattern recognition is the least as I was not able to understand theoretical content without hands-on experiments and assignments. The research guidance from my supervisor Dr. Soumya Jana has helped me in PhD as well as my job. His commitment to his students is invaluable.

Outings and Araku trip with my MTech batch mates are cherishable moments. Secondly, APJ Abdul Kalam sir visit IIT Hyderabad for interaction, and further offering a course. It is a memorable moment to see an ex-president teaching at IIT Hyderabad. As an IITian there is no need to worry about trivial things such as a job, stable income, etc. Give it a shot to make a significant contribution to your interest.

As a concluding remark, I just want to say that IIT Hyderabad is one of the premier institutes with the best faculties and research innovation environment. If you want to reach me, please mail me at: **sudhakar.modem@gmail.com** or **modemsudhakar@gmail.com**.

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