Slide 1:

Hi, this is Chengtao Xu from Minnesota State university, Mankato. I'm a graduate student studying Electrical engineering. Now I'm focusing on the application of low energy Bluetooth technology in Universal power converter system which sponsored by Xcel energy company. Also, my research interests include the application of communication system in renewable energy, the robotic control, and advanced control system.

Today, my presentation is about Low energy Bluetooth inter-node communication schemes via randomized reconfiguration. The work is done by me and professor Winstead of ECET department.

Slide 2:

Well, today, my topic will focus on the following parts in the slides. Firstly, I'll give some background information of BLE technology and how it related to our works.

Then, I'll give the communication mode we apply to use in my research works.

Later, we'll introduce two schemes related our research about communication latencies.

And after we apply randomized reconfiguration into one of the communication schemes, we 'll have the simulation results which related to it.

Finally, we'll give a brief conclusion of my works.

Slide 3:

Okay, so now, let me ask you one question, what is Bluetooth or how we'll use Bluetooth technology in our daily life? (wait 5 secs)

Yes, on our smart phone, we can use them to transmit video or record profiles, but seems it has a problem of high power consumption.

That's the basic impression for us before 2011, after that, BLE technology begin to show its benefits in short-range communication area, and actually the BLE technology is usually called Bluetooth smart or Bluetooth 4.x, which just has single BLE mode for transmission, it can communicate with old Bluetooth technology device by Bluetooth Smart ready.

Of course, we know that BLE's power consumption is less than Bluetooth technology with 20~100 times lower, it is coordinated with our project's requirement of power saving

Slide 4:

Compare with WiFi wireless communication technology which can realize node to node ad hoc network, however the Bluetooth low energy technology is connected by the specific communication unit which called piconet. In latest BLE technology which indicate the node which we can see from this slide, the bridge of S which means the slave device can be salve device a master device at the same time. Which provides better message transmission quality in real communication process.

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Here, we'll talk about how the BLE networks can format a scatternet by the node discovery process according to this psydocode.

We see that before the maxmimum time T device who sending the advertise package which request to connect into this BLE networks, in the mean time there is also some nodes keep scanning this area which covered by itself, once they receive a connecting request then it will change into the slave device in this network, also the device who send the message out will turn into master device. Both of them will keep the device unique Bluetooth address in their device address table.

Slide 6:

Table of slave and master device address in each node.

Slide 7:

So we all know that the physical world interference will trigger some communication latency during the communication process. Like N4 node wanna send out a message through N1 which is the bridge node, once there exist collision of the message transmission process, the message arrival time will be late than expected. And The transmisiion latency is critical to some real-time system especially in power flow transmission area. The real time power flow data is critical for utility to monitor the situation of current power transmission situation.

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So here is what my research works focus on, when we have multi converter in this power transfer system, we need use a low energy cost wireless communication way to make sure all converter can talk with each, then they can transfer back the message to the utility for other usage way.

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So our research problem is how to use less power consumption to realize the wireless communication networks in this universal converter system, and how to choose the right communication scheme to minimize the transition latency to reach the destination of the master device.

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So according to our research problem, we' ll apply this communication mode to our simulation works about transmission latency, and here we have a few assumptions, like we auume the communication packet are of a uniform length and content.

Also, all nodes require same communication capability with the same transmission latency Ttx, which is not include the discovery latency which is one pretty important latency factor in configure a BLE network.

And all nodes are assumed to have the same power flow data capture capability leading to a contant latency for data capture Td. In which Td is larger than Ttx.

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So here we apply two communication schemes, the first one we proposed is Asynchronous scheme. Based on our assumption previously, we have the periodic power flow data accrosing all BLE devices. The data capture latency is proportional to message transmission latency. Then we can get the likelihood of collision happened during the transmission process. And we know that the ideal time for all slave node transfer package to master device needs N minus one times transmission latency.

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So now, we consider the other schemes, synchronous scheme, them master device will send a data request to all slave nodes till the left end of this straight BLE devices lay out. Later all of the slave devices will transmit back the power flow data back, in which the total transmission time would be the i th node transmission time plus data capture time. Then we have the total transmission time of it would include the data capturing time Td and transmission time of sending request and retrieve the data process.

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Compare with two schemes here, which we found out an odd results which the synchronous schemes requirement of time is larger than asynchronous one. However, we may need to add the collision happened in this asynchronous process, and specifically, it has 2 transmission time required for each collision happened in one node.

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Then here we applied an uniformly distributed offset, and according to possibility theory in math, the mean of the offset in this distribution is zero, and the aggregate additional network data transfer delay is zero. And the likelihood of collision happened in this randomized reconfiguration way is the ideal transmission time in asynchronous scheme time the likelihood of collision happened in one node.

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After we doing the simulation using virtual node for these two schemes, the minimum expected mean latency is 0.12s which composed with ideal transmission time and latency for collision within 10 nodes.

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And we can see number of collision happened within 10 nodes which approach to uniformly distribution after we applied enough experimental time it. We also assume a Poisson process here and mean arrival time of the data are constant.

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Finally, we have the mean latency of simulation in asynchronous scheme is approximated 0.23s after adding the randomized collision happened in this network.

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Furthermore, we have the simulation results of latency for two schemes which related to the total number of nodes in this network. From this, we can see that the synchronous schemes latency is still larger than the asynchronous one. Which give out an important results, that is the asychrnous scheme which might provide more flexibility of power flow data transfer ways in power converter's communication with utility.