**IEEE P802.15**

**Wireless Personal Area Networks**

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| Abstract | [Minutes of March 2015 Plenary Session]  |
| Purpose | [Description of what the author wants P802.15 to do with the information in the document.] |
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**Task group 802.15.7r1 met for 8 sessions during the March 2015 meeting.**

**Session 1 (09 March 2015)**

**PM 1 (13:30 – 15:30)**

Yeong Min Jang (Kookmin University) – Chair

Attendees:

* Prof. Oshima – Panasonic in Osaka, 5 year old project to develop OCC. Transmitter is any lighting source and target is signage
* Hideki Aoyama – Panasonic Japan
* Rojan Chitrakar – Panasonic, Singapore R&D labs
* Yeong Min Jang – Kookmin University, South Korea, VLC work on LED ID for the past 7 years in Korea. ETRI interest in VLC/OCC and other companies
* Soo Young Chang – California State University Sacramento, previous active involvement in the 802.15.7 standard
* Rick Roberts – Intel, VLC with focus on camera communications
* Prof. Tuncer Baykas – Medipol, Istanbul University interest in OCC and OWC
* Prof. Murat Uysal (Ozyegin University) – high speed OWC
* Dr. Volker Jungnickel – Fraunhofer Heinrick Hertz Institute Berlin, focus on OWC for last 60 years with interest in high speed
* Nobuo Iibuka – Casio, OCC low data rate focus
* Dr. Zeng Yu – China Telecom, Research Institute in Beijing, Smart Cities with focus on OCC and VLC

Chair went through the patent policy slides (<http://standards.ieee.org/board/pat/pat-slideset.ppt>) and mentioned that there is some changes in the IEEE patent policy and the updated patent slides will be posted when available.

Volker mentioned that he would like to show a demo of their technology and requested time for it.

Rick mentioned that Jaesang Cha has yet to submit the contribution for LED ID link in the home page.

Rick went over the OWC tutorial (DCN 15/112). The committee agreed that the companies that are physically present in the session will present their material in the prescribed order and those that are absent will be put at the back of the queue.

Rick Roberts presented the Intel contribution to the Call For Applications (146-00).

* Focus on OCC with integration of Image processing and Data transmission
* Policy of favouring RF
* Use OCC for Location Based Services (advertising and positioning)
* Use of Location Data to improve security of WiFi/RF protocols
* Flashing QR codes for high-speed OCC
* Photogrammetry to determine indoor positioning. Determining use location based upon angle of arrival
* Determining the orientation of the devices cannot be done with RF, but it can with OCC because you can determine all 3 axis (X, Y, Z).
* Comphotogrammetry – the merger of CamCom and Photogrammetry such that light sources become self-identifying anchor features.
* Cost Effective price point for implementation of CamCom with car-to-car communications as in-car cameras grow
* OCC with MIMO
* Requirements of standard:
	1. PHY mode that works with both/either Rolling Shutter or Global Shutter
	2. PHY must work when the LED light is a point source
	3. PHY must support simultaneous ingest of data from multiple uncoordinated spatially separated LED light sources.
	4. PHY must support MIMO support for multiple coordinated LED light sources
	5. PHY mode that supports LED light source to be identified at a low camera frame rate and then demodulated at a high camera frame rate using region-of-interest sub-sampling
	6. PHY mode that supports OCC transmission, at very short range, in excess of 100 Kchips per second using camera frames rates equal to or less than 30 frames per second.
	7. OCC MAC mode that supports unidirectional data transmission from one or more coordinate or uncoordinated LED lights.
	8. MAC mode that supports repetitive informational broadcast ata very low data rate; that is, the frame format has very little overhead and is optimized for short payloads sent in a repetitive manner.
	9. OCC dimming with PHY modes with the above requirements based upon Pulse Width Modulation.
* Volker – co-existence with current 802.15.7 version must be considered
* Yu Zhen asked if we need to follow the 2011 specs?
* Rick: Since we are doing a revision, everything in the previous standard can be changed if needed.
* Volker: What if the original 2011 specs is being used by people?
* Rick: We should be able to add a higher and a lower band in the existing 2011 spectrum without overlapping. We need to ensure co-existence.
* Chair: How easy do you think it will be to commercialize the standard?
* Intel: Standardization will make things easier but it doesn’t guarantee success with commercialization.
* Nobuka: Which of the nine points would be your priority?
* Rick: All are of equal priority.

Chaired by Yeong Min Jang (Kookmin University)

Chair called the meeting to order at 16:10.

**PM 2 (16:00 – 18:00)**

Nikola presented PureLiFi’s response to the CFA (192-00). Nikola also showed a video of the demo they did in the Mobile World Congress 2015 in Barcelona.

Rick: Current 15.7 has provisions for mobility, would that be able to handle your requirement.

Nikola: We are looking into it.

Jang: 15.7 does not provide detailed solution, only a rough sketch.

Rojan: I wonder if mobility is within our scope, it would usually be done in Layer3.

Rick: Is there any difference between Link Switching and handover?

Jang: 802.21 had defined 2.5 layer protocols to enable fast handover, could we use it?

Nikola: We need to look into it.

Volker: Latency is a big issue in handover.

Jang: What are the differences between VLC and LiFi?

Nikola: LiFi is a high speed, bi-directional, mobile and would be considered a subset of VLC.

Yu Zhen: Are you working on the reduction of the form factor?

Nikola: Yes.

Nikola: We are using Infra-red for uplink because very sensitive IR receptors are easily available.

Mr. Baykas : Why 4 IR?

Nikola: Just for redundancy.

Yu Zeng (China Telecom) presented a response to the CFA for OCC (180-00)

* Project a max data rate of 15 Gbps with a typical bandwidth of 90 MHz – 400 MHz.
* Focus on OCC with applications including data transmission, LBS, etc.
* Actively deployed OCC – based on QR code from device to device that dynamically changes. There is a need to standardize the scanning frequency of the cameras to guarantee interoperability.
* Pattern recognition with camera input, however, it requires network access.
* Pattern Identification using pictures, where the original image is comparable but not recoverable
* OCC Platform where Industry focuses on SDK input for industries that focused on Account Management, Content generation, Data analysis and Content Management.
* The Platform connects to the mobile devices.
* Requests
	1. One OCC PHY mode that supports VLC device power consumption monitoring and provide management abilities -> system that is optimized for low data rate power efficient communications
	2. PHY mode that support multi-data rate transmissions, eg., Low data rate, normal data rate and high data rate
	3. Minimum requirements for manufactured devices to be graded as meeting the IEEE802.15.7 OCC level of compliance in terms of connection speed and functionalities, eg., OCC – basic, OCC – standard, OCC – advanced, etc.
* Already have a Dynamic QR code application
* IEEE P1.8 -> power management standard for very low power devices and the IoT.
* Rick: Is Slides 6, 7 informational only?
* Yu Zhen: Yes.
* Nikola: Ref Slide 5, what about dynamic QR code would you like to put into the standard.
* Rick: Intel has the same application, although standalone QR code is common place, dynamic QR codes is new, we need to look into the sample of the QR codes.
* Nikola: Does iOS or android supports control of camera frame rates?
* Rick: We could make the standard first and then go and ask for the support.
* Nobuka: QR code may not suitable for long distance.
* Rojan: What do you mean by point 1 on slide 10?
* Yu Zhen: This is to improve the power consumption of the mobile devices and make provisions for e.g. of reducing data rates if battery is running low.

Jang: How do we overcome the limitation of blockage of line of sight for VLC?

Rick: VLC is not looking to replace or compete with RF, it is a completely different use cases.

Rick requested for agenda time on Thursday for joint Response to CFA by Intel and NTU.

Chair added the item to Thursday PM1.

Chair declared recess till Tuesday AM1.

**Session 2 (10 March 2015)**

**PM1 (08:00 – 10:00)**

Yeong Min Jang (Kookmin University) – Chair

Attendees:

* Prof. Oshima – Panasonic in Osaka, 5 year old project to develop OCC. Transmitter is any lighting source and target is signage
* Hideki Aoyama – Panasonic Japan
* Rojan Chitrakar – Panasonic, Singapore R&D labs
* Yeong Min Jang – Kookmin University, South Korea, VLC work on LED ID for the past 7 years in Korea. ETRI interest in VLC/OCC and other companies
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* Prof. Murat Uysal (Ozyegin University) – high speed OWC
* Dr. Volker Jungnickel – Fraunhofer Heinrick Hertz Institute Berlin, focus on OWC for last 60 years with interest in high speed
* Nobuo Iibuka – Casio, OCC low data rate focus
* Dr. Zeng Yu – China Telecom, Research Institute in Beijing, Smart Cities with focus on OCC and VLC

Chairman: New Patent policy is to be uploaded to mentor for review by all members

Prof. Gong, Gao, Xu submitted a response to the call for applications for LiFi that should be looked.

Informative contributions can be presented by other members of the committee, if a given member decides that it is sensible to be presented.

Contributions that should be included in the standard must be presented in person to the committee to provide an opportunity for committee members to ask questions on the proposal.

Nobuo Iizuka (Casio) response to CFA (173-01) – focused on OCC

* Use of Imaging, or special capability
	+ Obtain signal data and its position in the image from multiple signals regardless of the variety of background noise received from small / distance light sources
	+ Extend the functionality of the warning light
	+ Use existing cameras
* Use of flicker to transmit information is positive if you need to attract attention
* Easy integration in the camera means the market can be launched quickly
* Demos:
	+ O2O – communication from signage, where a short bit sequence is used to retrieve information from the cloud (images, songs, etc.)
	+ IoT – appliance LEDs blink when there is a problem. The camera pointed at the device brings up information related to the information (manual page, instruction vide, support, etc.). Developed parallel ID decoding with multiple blinking lights. General blinking pattern is available for download but the coding scheme is closed.
	+ M2M – multiple warning lights being picked up by the security cameras to convey status data where there is no need for high speed communications. At least 10 different events being tracked/decoded simultaneously (10 cm sized light can be decoded at 10 m), based on Windows SDK.
		- Robot vision can be issued commands to move, collect, stop, etc. using blinking lights in the vision area of the camera.
* Use of RGB diodes are required because you cannot transmit sufficient data in the time requirement (3 sec for the user experience, 2 sec is access to the cloud, therefore must acquire all data in 1 sec).
* Colour coding is required to distinguish the signal from the background, with 20 bits being decoded.
* Current implementation needs only 2 x 2 pixels to be exposed, however, you need more to account for movement and lighting conditions with the iPhone 6 providing 12 simultaneous points and PC can achieve 50 or more (limit by processing power).
* Increase security of the data by using Hash codes changing over time.
* Technical Features of the standard
	+ Allow multiple simultaneous reception of images (in any environment, easily discover and receive plural signals that are stable)
	+ Image acquisition on an ordinary camera to support simultaneous detection
	+ Use at distances of 0.5 m ~ 100 m or more
	+ Unidirectional, Low Speed, ID Beacon or simple data transmission
		- Low speed pulse rate 5 Hz – 120 Hz
		- Acceptable short format to ensure acceptable response times even at low speed

Hideki Aoyama (Panasonic) response to the CFA (197-00)

* Use for guide board/signage to offer extra information
* Use for guide board translating service offering translated info to each language holding smartphone over the guide board/signage
* Shopping mall or café signage for extra advertising/information
* Technical requirements
	+ Flicker of lighting fittings must be imperceptible when the ceiling lighting is used
	+ Original design should not be impaired
	+ No flicker for human eyes or cameras.
	+ Communication rage includes 0.1 – 10 meters
	+ Uses reflected light
	+ Supports short (8 – 128 bits) ID transmission within a second.
	+ The PHY layer must support information coming from at least 2 or more signage/sources simultaneously.
* Security cameras operate at lower frame rates and therefore we need flexibility
* Frame rate is unstable in most cameras, might need to be changed in future
* Distance is not a consideration because the assumption is uniform exposure
* Consider the health impact of each idea such that it does not induce epilepsy, etc.

**AM2 (10:30 – 12:30)**

Attendance in addition to 09 March 2015 and AM 1 on 10 March 2015

* Prof. Suk Chan Kim (Pusan National University) – interest in VLC
* Prof. InChul Jung (Sungkonghoe University) – VLC focus from Nakagawa lab
* Henry Frei (Osram) – working on VLC for several years and looking for commercialization

Rick Roberts, review of the tutorial presented at the 802 tutorial session presented on 09 March 2015 between 21:00 and 22:30.

Discussing the LiFi aspect, it was concluded that the 802.15.7r1 MAC and PHY must provide support for the fast handover and multiple access that is required to enable this functionality. This functionality should help with Interference Coordination mechanism, Hand Over, Multiple Access, etc.

Higher layer functionality must be provided by the 802.2 or other external groups.

* LiFi interested should become familiar with the stack provided by the 802.2
* 802.15 Management Information Base – a multiple depth pattern/control plane that allows storage of relevant information.
* 802.16 and 802.11 stack coordination and MAC should also be considered

Committee agrees that a “LiFi Alliance” (Industrial Association) is required to really push the technology forward on a broad scope and attract market interest. This should be formed sooner rather than later.

Volker discussed the benefits of using optical-OFDM with from inception to the evolution today.

Volker to present an overview of optical-OFDM in the Vancouver meeting.

Potential integration with 802.15.9 for the security/privacy improvements/additions to LiFi. Draft standard has been released and it would be useful if some members familiarize themselves with it.

Volker already have VLC systems that have <3ms latency. Practical results to be shown in 6 – 8 months.

Volker, LiFi should support multi-link support for example MIMO, angular diversity receivers, etc. to drive very high level of robustness.

Osram, OCC is first to be addressed because it is simple to incorporate and easy to be brought to market. LiFi will be later in the market development.

Jaesang presented the LED-ID concept. The distinction between the LED-ID concept and the OCC use-cases are still not clear.

Chair declared recess till Wednesday PM1.

**Session 3 (11 March 2015)**

**PM1 (13:36 – 15:30)**

Attendance:

* Murat Uyasal (Uzyegin University)
* Henry Feil (Osram)
* Soo-Young Chang (CSUS)
* Prof. Yeo Min Jang (Kookmin University) – Chair
* Dr. Volker Jungnickel (HHI)
* Rick Roberts (Intel)
* Zeng Yu (China Telecom)
* Prf. Oshima (Panasonic)
* Hideki Aoyama (Panasonic)
* Rojan Chitrakar (Panasonic)
* Nobuo Iibuka (Casio)
* Dr. Nikola Serafimovski (pureLiFi)
* Prof. Tuncer Baykas (Medipol)
* Koji Horisaki (Toshiba)
* Qian Li (RITT)

Volker discussed the details of the demonstration system

FOV – depends on the lens, publicly available 7mmsq effective area for PIN, Lens to focus the beam with a smaller lens giving a larger FOV and smaller gain, typical trade-off

Power – variable depends on data rate (max is 30W for the whole unit for high data rate), Power amplifiers are switched off when the packets are at low data rate (5 – 10 W baseline) with power consumption increasing with data rate.

Selling the system in low volumes (can send an offer).

Fraunhofer earns 1/3 of money from industry by establishing contact, sold several of the links

TDD chipset and fully symmetric, chipset provided by off-the-shelf vendor

Moved from FPGA to the chip but not fully adaptable to the versatile applications (mimo, low latency, etc.)

BB chip is not important for power, rather than the LED and the wide-band amplifier for power consumption. Can use any OFDM chipset.

Fast switching phosphor can be used to increase the efficiency of the speed of the white LEDs and increase the SNR and data rates.

Blue light LEDs can switch at 10 – 20 MHz.

Can use white light, but the bandwidth decreases

Photon energy is greater at the lower wavelength, therefore physically speaking silicon photodiodes will be more sensitive to the red/IR area.

Avalanche Photodiode receiver design is 100x more than normal photodiode receiver circuit. Using good TIA, the performance can come to similar performance as APD. Analogue design is critical to achieving this increased performance (Jelena at HHI).

Chair presented the Kookmin University response to CFA (242-00)

* Data decoding procedures of OWC
	+ Rick: Why is the global shutter shown to expose the entire image sensor? It depends on the distance
	+ Chair: Here we assume that we are near the light
	+ Rick: Why is the SNR for the Global shutter low?
	+ Chair: I need consult my student
	+ Rick: Why are we considering Skew and Wobble?
	+ Nobuo: Global shutter has blur, but Skew and Wobble are only Rolling Shutter effects
	+ Standard should support Global shutter and Rolling Shutter simultaneously
* Asynchronous rolling shutter based OWC
	+ Confusion about the data rates presented from the RS effect:
		- At distance of 1m can achieve up to 600 bps
		- At distance of 3m distance can achieve 8bps
	+ Chair: Depending on the transmitter, the data rate will change
	+ Nobuo: What are you trying to say with the slide? If someone wants to use the Rolling Shutter, they must control the exposure time, etc. Why is the distance a dominant factor in this event? The result is controlled by the exposure time and size.
	+ Nikola: The Rolling Shutter data rate changes with the distance depending on the relative size of the data communicating area (signage, LED light, etc.) as a percentage of the overall image (how many pixels are exposed).
	+ Rick: Writing a standard means that you must adjust for the distance and minimum data rates
	+ Nobuo: The exposure times are the key controlling aspect of the RS experiment as well as the global shutter.
	+ Nikola restated the limitations of the Rolling Shutter.
	+ Nobuo: Toshiba is not here and therefore may have a solution to the problem that Nikola has identified.
* LBS applications
	+ “Link switching” delay maximum of 120ms when you have a specific topology of overlapping cells
	+ Rick: did you do link layer switching in the MAC or the PHY?
	+ Chair: We have a management functionality at the link layer.
	+ Rick: This is out of the scope of this committee.
	+ Chair: There is a layer that sits parallel to the PHY and MAC that may be included in our standard.
	+ Rick: There is a specific standard 802.1 that deals with this transportation layer and it is a standard that we would need to integrate with
	+ Chair: We can introduce this in our standard.
	+ Nikola: As I understand, we do not have authority to work with the resource management and this is something that we would need to look at as a complementary.
	+ Chair: We can introduce this, we have the authority
	+ Rick: We do not. Do you have evidence to show this? Here is the 802.15.7 topology, there is no management entity
	+ Chair: Perhaps we need to have a management entity to introduce link-switching?
	+ Rick: There is an 802.2 entity that deals with the link layer specifically and no other group is allowed to work in the link layer.
	+ Chair: We need more discussion.
	+ Tuncan: This is law, we need to ask Bob or someone else that will explicitly tell us what is allowed or not.
	+ Rick: If you are talking about switching at another layer (PHY or MAC) then we can talk, otherwise we cannot do it.
	+ Chair: Let us invite Bob and the others to determine what we can do.
* Internet of LEDs
	+ Use-cases
	+ Nikola: What is the difference between OCC and LED-ID?
	+ Rick: I have never understood the difference between them either?
	+ Jaesang: OCC is generally only unidirectional, LED-ID is two directional. Cameras do not have the ability to be bidirectional. What else could be bidirectional? Tags, codes, flashlight.
	+ Rick: Is the unidirectional OCC the only difference with the bidirectional LED-ID?
	+ Jaesang: LED-ID can only be bidirectional and unidirectional.
	+ Nikola: What is the difference between between OCC and LED-ID aside from the name?
	+ Nobuo: What is the technical difference between LED-ID and OCC?
	+ Jaesang: I need to find the difference. It depends on a case by case scenario.
	+ Chair: Jaesang will provide a contribution in May to clarify the difference.
	+ Jaesang: Cameras need a transmitter, therefore the flashlight can be used or the screen with an LED-ID tag or something else but a different transmitter.
* Chair conclusion:
	+ PHY for unidirectional and bidirectional
	+ PHY for Rolling Shutter and Global Shutter with an application depended PHY and MAC layer.
	+ Link switching functionality for OCC and LiFi
	+ Put the IoT concept using LED, digital signage, display
	+ LED-ID operation – concept still needs to be addressed
	+ Moving functionality to the PHY reduces complexity in higher layers
* ITU-T is pushing to standardize the IoT sevices.
* Volker: How are we going to address objects in the space?
* Rick: In 802 we cannot define link level and networking addresses.
* Zeng: We need the authorities to tell us what we are allowed to work on
* Nikola: We must decide on how many bits will be required to identify objects. This has a direct impact on the size of the packets that must exist, therefore putting a limit on the data rate that each PHY must achieve for a good user experience.
* Rick: Need to put all these questions to the experts. Some OCC modes do not need to speak with the MAC

**Chair Questions for the Authorities:**

1. Can we operate on the Link Layer to support link switching?
2. How do we interface with to ensure Link Switching and how do we incorporate that?
3. What is the minimum size (bits) of the identifier for each object? Who defines this?
4. 802.15.10 – Layer 2 Routing: Can we interface with this to understand what they do?
5. How do we change the name?

Rick to provide input for “Lessons learned from IrDA” and what is the current PHY layer switching in 802.15.7. Is this suitable to move forward?

Yoe Ming Jang response to CFA (243-00)

* OCC issues
	+ Uplink
	+ Line of sight interruption
	+ Cell overlap
	+ Backhaul network & supporting network
	+ Murat: The difference between LiFi and OCC is the speed and the underlying receiver. Specifically, LiFi uses a photodiode where interference mitigation is different from OCC that uses imaging sensors where special resolution may be done with image processing.
* Optical MIMO
	+ Volker: We built this 15 years ago and it was extremely difficult. How can this be solved today? How far is it from the market? If the market wants it, then the technology can be effective.
	+ Rick: We have technology that can resolve MIMO with an image sensor.
	+ Nikola: This is not yet practical for high speed.
	+ Rick: We can do it with OCC today and if LiFi wants to have it, then you need to decide what you will incorporate.
	+ Murat: We can have transmit side diversity incorporate and there is work that we can look at for receiver diversity.
	+ Chair: MIMO with opportunistic selection.
	+ Nobuo: MIMO is a mathematical concept.
	+ Rick: This mathematically MIMO with a sparse matrix.
	+ Chair: Multiplexing and diversity for OCC MIMO, Spatial Separation of pixels, Transmitter and receiver alignment problem
	+ Volker: If you start working with MIMO, then this is will become an endless discussion. If you have a meaningful and implementable scheme with your student, then we can consider it. Otherwise, we will get lost.
	+ Jaesang: We need to consider the diffusers for lights and how that impacts MIMO. Impractical solutions should not be considered and practicality is important.
	+ Rick: We need to consider the standardization model.
	+ Murat: We might need reference channel models to develop work for the system.
	+ Rick: OCC channel model is LoS and is easy. LiFi needs more complex channel models that might be problematic to take longer. This is not addressed currently and it can take a very long time.
	+ Murat: I can present something in Hawai for July meeting that can be useful.

Chair adjourned the meeting until PM2.

**PM2 (16:15 – 18:15)**

* Chair continued the presentation of (243-00)
	+ Chair: Asynchronous Scheme is applied to mitigate Variation in Camera frame rate.
	+ Chair: The standard must support MIMO and both colour and monocolor data transmission.
	+ Nobuo: The current presentation is too much implementation dependant and therefore not a standard.
	+ Jaesang: QR code is limited and needs color
	+ Murat: Is QR code standardized in IEEE or somewhere else?
	+ Tuncer: The QR code is standardized as ISO and therefore work in this, should be addressed there.
	+ Tuncer: Colour can be part of the standard and should be considered.
	+ Chair: Bidirectional communications can be done with the camera on the smartphone and the display can be used to convey the message.
	+ Nikola: What is the use case for it?
	+ Rick: Near Field Comunicationss
	+ Zeng: We have implemented colour QR, but it was not successful because the cameras were not good and there is a drift in the colour that causes problems.
	+ Chair: We have it but it only works with 3 colours.
	+ Nobuo: What is the difference from the user perspective and the technology?
	+ Rick: Near Field Communications is expensive to integrate into devices and the integration is difficult and time consuming.
	+ Nobuo: We have already implemented a point to multipoint communications using the camera and the flash-light.
	+ Rick: Contribution will be required to define the colour patern and other aspects.
	+ Jaesang: You can potentially use multiple colours and multiple cameras can be used to combine the screnes.

Volker: response to CFA (248-00)

* High data rate coverage in large areas
* Multiuser support
	+ Using OFDM, would be better to support OFDMA or FDMA for multiple access due to lag rather than TDMA.
	+ Rick: Is most of the communications with the Network or within the users?
	+ Volker: It would need to go up to the external network.
	+ Nikola: Most of our use-cases are focused on communications with the external network.
	+ Rick: 802.15.7 has support for peer to peer with switches in the MAC
	+ Volker: Any complexity in the MAC will need to implemented very efficiently which is difficult.
	+ Nikola: We need to form two parallel tracks (additional teleconferences groups) that will look at LiFi and OCC separately. At the IEEE meetings, the two groups come together and present the status to review progress and just vote.
	+ Rick: The two processes seem to be sufficiently different so that there is not too much interference.
	+ Rojan: We need to parallelize the processes to speed up the standardization.
* Mobility support (handover)
* Interference coordination
* Challenges:
	+ Reduce complexity
	+ Keep the high performance
* Include native multipoint-to-multipoint support in a LiFi system
	+ Rick: Enabling handover a multipoint to multipoint scenario will be very difficult without having access to the higher layers.
	+ Nikola: We need to do the best we can to achieve what we can within the limitations we have.
* Use Case: Backhaul for small mobile radio cells
	+ Low-cost
	+ Rate adaptive OWC PHY is needed
	+ Rick: Light Point products have alignment parts that are delivering 2 Gbps. Will you need these parts to be in the standard?
	+ Volker: Not at all, the LEDs are diffused and therefore have a wide area of communications and are immune to sway.
* Use Case: Personalized Manufacturing Cells
	+ Use OWC for the cable replacements on robots
	+ Robots should move and be connected with >1Gbps and <1ms latency, reliable with a multipoint to multipoint connectivity
	+ Volker: We should be able to cover this scenario within the next year.
* Use Case: Precise Indoor Positioning
	+ High-speed sequences
	+ Time of flight measurements done in the network
	+ <5CM spatial resolution was demonstrated to date
	+ Include support for positioning into bidirectional OWC.
	+ Volker explained how to perform indoor positioning with bidirectional communications
	+ Rick: This will have consequences in the PHY and MAC. You need to look at the 802.4a for how to implement raging and other aspects that would be suitable. There need to be time-slots allocated to achieve the high precision.
	+ Volker: Yes, we need to operate without contention or coordinate with known contention to ensure it is successful.
* Use Case: Car to Car Communications
	+ Design OWC PHY and MAC according to C2C requirements
	+ Rick: 802.15.5 is dealing with mesh-networking for C2C communications and networking
	+ Volker: 802.11p has C2C considerations, but for 802.15.7r1 needs to support very quick channel adaptation and data transmission
	+ Volker: As soon as we have a link with quicker link adaptation we can show this immediately.
	+ Jaesang: Combining a hybrid solution for OCC and LiFi would be a more comprehensive solution.
* Bidirectional PHY and MAC to achieve
	+ 10 Gbps at least in the downlink
	+ MIMO to achieve reliability and high data rates
	+ Multiple users in parallel (TDMA, FDMA, ODFAM, etc.) to minimize latency
	+ Precise positioning using “ranging” measurements, for handover and interference coordination
* A higher-layer interface that supports handover and cooperative signal processing with negligible impact on latency

**Session 4 (11 March 2015)**

**PM1 (13:36 – 15:30)**

Attendance:

* Murat Uyasal (Uzyegin University)
* Henry Feil (Osram)
* Yeo Min Jang (Kookmin University) – Chair
* Dr. Volker Jungnickel (HHI)
* Rick Roberts (Intel)
* Zeng Yu (China Telecom)
* Prof. Mitsuaki Oshima (Panasonic)
* Hideki Aoyama (Panasonic)
* Rojan Chitrakar (Panasonic)
* Nobuo Iibuka (Casio)
* Dr. Nikola Serafimovski (pureLiFi)
* Prof. Tuncer Baykas (Medipol)
* Koji Horisaki (Toshiba)
* Qian Li (RITT)
* Prof. Jaesang Cha (Seoul National University of Science & Technology)

The Committee looked at the contribution from The University of Science and Technology of China. It was concluded that it addressed some technical aspects of the LiFi use cases that were covered by Nikola and Volker previously.

Rick Roberts discussed the response to the CFA from NTU (203-00).

* Frequency-shift-keying Rolling Shutter technology for Universal Camera Communications.
* As you change the blinking frequency of the light source as being observed by the camera and knowing the size of the object, then you can determine the frequency that is being sent.
* Standard should support
	+ PHY that supports rolling shutter CamCom in line of sight scenarios
	+ PHY that can cope with loss of a large portion of the signal samples due to (1) long time gap between exposure periods of consecutive image frames, (2) large Tx-Rx distance (3) unsynchronized Tx & Rx
* Henry: How do we cope with different bit size and locations specific?
* Rick: We can do location depended information that might not need to retrieve anything.
* Nikola: We need to think about how the localization identifiers will be considered. Is 128 bit IPv6 necessary? How do we achieve this addressing?
* Rojan: Do you want to be at Layer 2 or Layer 3?
* Nikola: I don’t have a preference, we need to consider it.
* Rojan: We have 802.6LoWPAN that uses the higher layer to do the translation between IPv4 or IPv6 and ZigBee. We should consider this moving forward.
* Henry: We need to discuss this further

The additional teleconference groups were discussed. Tuncer, Rick and Nikola agree that the work needs to be done prior to arriving to the meeting and only to contributions should be revised when we meet together.

Jaesang: We need to discuss the additional teleconferences meeting concept moving forward in Vancouver because teleconference is difficult for me to work with.

Murat: We can have additional teleconferences groups for OCC and LiFi, then Jaesang can agree if they want to have LED-ID additional teleconferences groups.

Tuncen: If we are going to wait for every decision for 2 months, then we are going to be too slow. We need to agree whether we have this or not now.

Nikola: Absolutely agree. We need to come to a decision.

Jaesang: We need to wait to get the input from more industry

Chair: We need to get input from the rest of the world

Nikola: We need to get the groups to work quickly and push LiFi and OCC in parallel.

Tuncer: We have invited everyone for 2.5 years now and we must make progress quickly. We are here and the committee needs to move forward with these people

Osram: We need to have progress as soon as possible.

Nobuo: We need to work between the face-to-face meetings

Rojan: We agree that we need additional teleconference groups to move forward with the work.

Rick: I am happy to move forward with additional teleconferences work on any kind.

Zeng: We need to have a conference call to work.

Jaesang: I am a Professor and I need to work on other work. I don’t know what is the deadline to drive the standardization? LiFi group wants to push quickly and how do we best harmonize the two concepts. OCC needs more discussion and LiFi wants to be quick. We need more face to face discussions.

Rick: As a corporate member, I am ready to walk in with a proposal at the next meeting. I don’t agree that we should go slow. The OCC group can agree on everything before they walk into the meeting and be done. Us and other corporates have stuff already working.

Volker: It should be possible to have work done on the side and then move forward with decisions at the meeting.

Rojan: The telecom is to get the technical details out of the way and the decisions need to be made at the meeting.

Chair: Should we change the schedule to match the work?

Rick: We should be continuously revising the schedule as the standard progresses.

Rick went through the schedule, it was concluded we are ahead of schedule and we need to move faster.

Rick: We can start working on the TRD now and be ready for the Vancouver meeting to start with a coherent CFA response. This will form the basis of the TRD by looking at what the people are asking for. There is a lot of manual work that needs to be done before it is presented before the committee.

Chair: We have already sent out the call for applications and we need to wait for more input from the academia.

Tuncer: We can always look at CFA and then decide if it works.

Chair: There are more companies that want to contribute to the standard and we need to allocate more time for them to contribute. There are companies in Korea that want to contribute to the standard.

Rick: We are a business and we are not a TSK Group. We cannot wait for input from people within everyone in the world. We need to get this done.

Rojan: As a company, we need to work to get this done as quickly as possible.

Volker: We definetly do not have all the partners involved here that can contribute to the standard. We have some partners that would like to contribute and include in them in the process.

Rick: I don’t mind if we leave the CFA open. However, the TRD needs to be written and it needs to manifest.

Nikola: We cannot wait for everyone to have their say. We need to create the TRD as soon as possible and if they can contribute to the standard then we can determine if it is valuable, but the document must manifest and be written.

Chair: This is a good hybrid scheme. We still need more work to push this forward and open it up to more industry and more research institutions.

Tuncer: Can we get the documents done by the Vancouver meeting? Can the Technical Editors create the TRD as soon as possible by Vancouver?

Rick: Yes, I can also assign people. I would like to see more input, however, my company has been sending me here for a while and it is unfair that someone walks in at the next meeting and they have the same influence as me. I am not comfortable with someone coming in July or September and having the same influence as me. We need to put it under revision document where it will take 75% of the votes to change something.

Chair: Can we decide the milestones and then propose the timelines?

Rick: I am happy to create the next draft of the meeting.

Nikola: Let us combine the CFA for OCC and LiFi at the next session and simply shift the proposed activities from July to May and activities from September to July.

Jaesang: Please understand my special case where I have a problem with teleconference.

Nikola explained the voting process again after Rick explained it.

The committee agreed on the accelerated timeline.

Nikola, Tuncer, Murat, Volker. The Channel Models are used only for providing a base-line for comparing the proposals and the schemes. It is not to publish a paper, this is an old field.

Jaesang: We should push the finalization of the channel model to be later.

Tuncer: These are only timeline proposals. If we believe the model is finished, then we need to have a motion and a vote. The vote will decide if we have an acceptable channel model.

Nikola: Jaesang, if you have a contribution, then you are welcome to present.

Chair adjourned the meeting until PM2.

**PM2 (16:08 – 18:15)**

Chair called the meeting to order.

Jaesang: The channel model needs to address IR and UV wavelengths.

Nikola, Volker, Murat: The different frequencies just change the reflectivity of the surfaces which means that it is simply an input to the model.

RITT: Is this model part of the Standard?

Rick: No, it is a separate document that is referred to in the Standard.

Murat: I have results that show how the channel model changes with respect to the environment given a certain transmit power and receiver power. I have results that are in the same environment with a VL light source and IR light source.

Rick: We need to agree on what is the environment, transmitter and receiver, etc.

Nikola: We are not doing anything new. This is work that is well understood and published. We

Rick did a straw poll to ascertain if there is a strong preference for the timing. There was no uniform consensus on the topic.

Jaesang: I can contribute a channel model by July, but May is too soon. My channel model is not published, but papers or journals are not important for me.

Tuncer: We can incorporate input for the channel model from you to be included in the later stage.

Rick: We can leave the topic for now and the CFP does not need to include a channel model. Let us freeze the current plan and post the new schedule.

Chair: We need to discuss the additional teleconferences group forming.

Rick: I would like to schedule an additional teleconferences group for 1 April.

Volker: Can we move the meeting to the 8 April?

The committee agreed to a teleconference of **1 hour duration** on:

* **8 April 2015** (OCC) starting at:
* 16:00 Seoul/Beijing/Tokyo local time.
* 09:00 Berlin/CET local time.
* 08:00 UK time
* **15 April 2015** (LiFi) starting at:
* 16:00 Seoul/Beijing/Tokyo local time.
* 09:00 Berlin/CET local time.
* 08:00 UK time
* **22 April 2015** (OCC) starting at:
* 16:00 Seoul/Beijing/Tokyo local time.
* 09:00 Berlin/CET local time.
* 08:00 UK time
* **29 April 2015** (LiFi) starting at:
* 16:00 Seoul/Beijing/Tokyo local time.
* 09:00 Berlin/CET local time.
* 08:00 UK time

Details of the meeting along with the relevant **material must be available 48 hours before** the call.

ACTION: **Chair** to get information about the IEEE conference call tool to be resolved by 06 April 2015.

ACTION: **Nikola** to get information on PowWowNow to be used.

ACTION: **Rojan** to get information about join.me and determine how to best use.

ACTION: **Chief Technical Editor** will appoint Chair for every call on a case by case basis.

Chair: These are not additional teleconferences groups. They are simply conference calls to discuss OCC or LiFi.

Volker: Can we invite people to join our call that are not participants of the committee?

Tuncer: IEEE is an open contribution forum and everyone is welcome to join the calls.

Chair: Rick needs to upload the previous TRD to be used by everyone that wants to use the template.

Nikola: Are we going to harmonize the CFA responses or the TRD?

Rick: Anyone can put any document on the mentor system and they can be put on the agenda. The Chairman of the call will decide the agenda. For those that want to develop a harmonized CFA, which I think is a good idea, will be available and those that want to develop draft TRD can also upload them. If there is no document number, we will not consider that document.

Rojan: Do we need each company to develop a TRD? This may duplicate a lot of work.

Chair: We can leave it and let us see what is there.

Nobuo: What does harmonizing CFA mean?

Rick: We need a document that captures all of the CFA requirements from the different inputs. We need to dispose of all the issues that are unclear.

Rojan: How do we harmonize the documents? Verbally or written? If we create multiple documents that would be significant amount of doubling of work.

Rick: Any company is free to post a merged CFA. I will personally go through each of the documents and then see if there are duplicates and merge them.

Chair: We will have 8 time slots to meet with both OCC and LiFi being done.

Chair: Hideki Aoyama is the Vice-Chairman of IEEE 802.15.7r1.

The committee revised the closing report.

Chair adjourned the meeting until the 8 April 2015 teleconference and the May meeting in Vancouver.