IEEE P802.11
Wireless LANs

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| IEEE 802.11 Study Group on Light Communications November, 2017 Orlando Meeting Minutes |
| Date: 2017-11-08 |
| Author: |
| Name | Affiliation | Address | Phone | Email |
| Volker Jungnickel | Fraunhofer HHI |  |  | volker.jungnickel@hhi.fraunhofer.de  |
| John Li | Huawei |  |  | john.liqiang@huawei.com |
| Nikola Serafimovski | pureLifi |  |  | nikola.serafimovski@purelifi.com  |

Abstract

Study Group on Light Communications meeting minutes from the IEEE 802.11 Kona meeting, September 2017.

**IEEE 802.11 Study Group on Light Communications**

**Monday, November 6, 2017, AM1 Session**

Attendance: around 25 people

1. The IEEE 802.11 LC SG meeting was called to order at by the Chair, Nikola Serafimovski (pureLiFi).
2. The Chair reviewed the IEEE-SA patent policy, logistics, and reminders, including meeting guidelines and attendance recording procedures.
	* It is reminded all to record their attendance.
3. Chair introduced the schedule for the week

– Press release on SG, contributions, CSD and PAR

1. Approve the minutes from the July meeting
	* Chair asked if there is discussions. No discussion. The minutes were approved.
2. Chair discussed press release on SG LC
* PR is in document no. 1589/r0
* Nikola said that timeline is longer than expected and PR is not ready yet
* Osama suggested to remove “airplanes” from list of use cases
* Christophe said not to change too much at this time
* Discussion in the group showed more people speaking in favor of keeping than removing it
* Decision was to keep it
* Osama noted that work in 802.15 should be mentioned in some way
* There was a discussion showing that any minor change proposed would be misleading
* It was decided to upload a revised version 1589/r1 and present it at the WG opening plenary
1. Gaurav presented 1587/r0
* Proposed to break the MAC into lower and upper parts
* Full duplex makes MAC layer complicated, RTS/CTS/ACK is split over separate channels
* It is said on slide 5 that LC has lower latency and needs to wait for RF
* Volker objected against this because if both media have same bandwidth and same channel access scheme, there should be no difference in the delay, same issue on slide 6
* Half duplex can reuse the existing 802.11ad MAC layer
* OSAMA asked if MPDU aggregation is used, answer was yes
* Because of higher bandwidth, GCMP encryption is suggested
* Volker asked if the upper/lower MAC is fixed in 802.11
* Joseph said it is no official break, OSAMA said that the lower MAC is essentially HW
* Nikola asked for some more explanation of the graph on Slide 13
* Gaurav will make a number changes of according to the discussion and upload 1587/r1
1. Nikola presented 1590/r0 coauthored with Ivica
	* Handover between different LC would need to be addressed
	* Heterogeneous network management and reliable data recovery would need to be addressed
	* Wide span of data rates demonstrated in slide 7
	* Mark mentioned that low data rates should not be considered, rather something for AR/VR with uncompressed video
	* Trade-off between data rate and coverage in slide 8 is important
	* Volker asks if 200 Gbps mentioned as upper limit demonstrated shall be the upper limit which would complicate the standard
	* Nikola says that 100s of Mbps will be the right scope for this standard
	* Volker also spoke in favor of beyond 1 Gbit/s to enable near-term AR/VR use cases
2. Nikola presented 1609/r0 co-authored with Simon
	* offloading from cellular to Wi-Fi
	* same is expected from Wi-Fi to LC
	* highlights consumer opportunities due to SDR and IoT
	* highlights business opportunities in smart buildings, enterprise and transportation
	* requirements on LC
	* Volker sees some technical contradiction between reqs. on Propagation and Avaiability
	* Christophe asks where the numbers of 10 LEDs per sqm and 10 devices per LED come from
	* Volker recommends to specify a mininum and a maximum value for each required parameter in the table on slide 13 and define the range within which the standard can be operated in this way
	* The group further discussed the coverage issue, which depends on analog frontend
3. Nikola presented 1649/r0 co-authored with Chen who is available in the next SG LC meeting
	* Discussion on path loss exponent in RF <6 GHz is 2-3
	* With light it is between 4-8
	* Comparison between coverage of high data rates
	* LC covers high data rates in smaller areas
	* Volker asks for clarifications on the simulation conditions, is same illumination assumed for µLED and OTS LEDs 🡪 will be asked to the authors
	* Data density comparison>25 Mbps/m² in 10 m with LC, 2 Mbps/m² in 100 m with 11ax
	* Volker asks for inclusion of 60 GHz would make this study complete
	* Transmission delay
	* Simultaneous UL/DL
	* MU-MIMO
4. Meeting recessed

**Tuesday, November 7, 2017, AM1 Session**

Attendance: around 25 people

1. The IEEE 802.11 LC SG meeting was called to order at by the Chair, Nikola Serafimovski (pureLiFi).
2. The Chair reviewed the IEEE-SA patent policy, logistics, and reminders, including meeting guidelines and attendance recording procedures.
	* It is reminded all to record their attendance.
3. Chair reviewed the schedule for the week

– Press release on SG was done, contributions are ongoing, CSD and PAR are ahead

* + Discussion on PAR and CSD will be on Thursday AM1
	+ Updated agenda was approved
1. Nikola Serafimovski (PureLiFi) presented a multi-author contribution in doc. 1643r1 coauthored with Olivier Bouchet (ORANGE).
	* **First use case is VR/AR with interaction**
	* Handle high definition untethered HMD
	* Aims at more than 100 Gbit/s uncompressed HD video transmission
	* 8k per eye 30 bit/pixel at 120 fps, 3 ms or less latency, multiuser, tracking <1mm, orientation 1/10°, energy feed
	* OSAMA asked for interference between LC which is there, in case of overlap
	* Bryan asked for time dialation, Nikola postponed the answer to later meeting
	* Tillac says (some minutes later) that VR/AR requirements are set too high taking display technology development into account, motion sickness is biggest challenge, caused by latency and refresh rate, should look at more near-term use cases
	* Volker said requirements are feasible in 10 years from now, would be good to develop a roadmap what is feasible in 3/6/10 years from now
	* Tillac would focus first on mass marlet use cases in households/shopping malls, 1 Gbit/s minimum, requirement is more constant, 3-4 users per room, 3x3 m, VR HMDs untethered are coming out, CPU are embedded in the headset, but is not powerful enough, should be moved into the cloud, IMT 2020 will probably be enough for content required in short term/current generation, entire latency including motion/rendering, less than this for wireless transport, Today there is no technology available which can satisfy data rate/latency requirements
	* **Second use case is smart office**
	* significantly relaxed requirements
	* **3rd use case is stadium**
	* Many people in ultra-dense environment
	* Requirements come from NGMN White paper
	* 20-50 Mbps/user, 3000 users/km2, 3.75 / 7.5 Tb/s UL/DL, stationary/pedestrian users
	* OSAMA mentions this is use case for 802.11ax, is asking to concentrate on use cases that are more specific for LC, Volker said that standard should cover all potential use cases and we don’t know what use cases will be in the focus in 5-7 years from now
2. Nikola Serafimovski (PureLiFi) presented a multi-author contribution in doc. 1648r0 submitted by Simon Bazin (FACTEM).
	* **1st UC is Wireless headset to aircraft crew (cockpit), wireless for more comfort**
	* Fully operational whatever the ambient light conditions are
	* Up to 4 headsets served simultaneously
	* Mass market solution which can address this
	* Coexistence with Internet
	* 1 AP, up to 4 terminals, near-infrared wavelength 890 DL/940 UL, 2 Mbit/s per user, latency < 3 ms per user, PER < 10-4, full duplex PHY, tackle different streams (data / audio) in parallel, QoS support
	* Volker commented that full duplex can be emulated by time duplex if enough bandwidth is used
	* OSAMA wanted to clarify that white light cannot be used
	* It was asked what happens if LOS is broken, Nikola say this is solved by appropriate deployment of transceivers, how many and where they are placed, implementation-dependent
	* Volker says this can be solved by MIMO and switching between the distributed access points
	* It was asked if radiation from sun/IR will hurt the transmission, Nikola says this is frontend design issue, optical filtering can be helpful and needs to be designed
	* Christoph says group should be focused on mass market and not so much on niche markets
	* John came back to the point of full duplex is not fully clear, Nikola agrees that the requirement can also be met by TDD
3. Nikola Serafimovski (PureLiFi) presented a multi-author contribution in doc. 1662r0 co-authored with Minoru Komori (Ushio).
	* **1st use case is shopping center** (treasure hunting area), shall stimulate customers sales interest
	* Use of LC is localization, not the most challenging use case for that but should be considered, other advantage is no interference with Wi-Fi
	* **2nd use case is Projection Mapping**
	* Provide information where the people are, using a wide range of wavelength
	* Volker asked for clarification how this is implemented (LED array/scanning laser beam)
	* **3rd use case is Virtual Reality with multiple people**
	* Overall requirements 10Mbi/s to 1 Gbit/s, <6 ms latency, 300 lux or higher, 200 nm to 2 µm
	* Christophe mentioned UV health issues, shall be regarded
	* Sang-kyu asked if there is any problem in TG13 and 802.11 with data rates, Nikola answered that this issue has been clarified in advance, e.g. in the Tutorila presented in Berlin
	* John asked about the light flux of 300 lux
4. Mohamad Noshad (vlncomm) presented a multi-author contribution in doc. 1686r0.
	* Weakness of RF networks are vulnerability to cyberattacks (man in the middle and others) and reliability of the network to interference caused by other devices
	* **1st use case is V2V**
	* Intra-and inter-vehicle networks, hybrid LC/RF network to reduce interference
	* OSAMA asks if the light can be used during the day, answer is that light is on during the daylight, there are infrared technologies like LIDAR also based on optical technologies
	* It was mentioned that this use case is also addressed in 802.15 by other technologies, there should be unique identity and not targeting everything
	* **2nd Use Case is Manufacturing**
	* Wi-Fi causes interference on RF devices, LC is a good alternative
	* **3rd use case is LC for power plants**
	* Interference issues can be overcome by LC
	* **4th use case is nuclear facilities**
	* RF EMI issues and cyber security requirements
	* **5th use case is use of LC in secure offices**
	* Presentation highlights the leak of signal through open windows
	* The bigger risk is at night, eavesdropper would need a big lens (1 m diameter) to get access to information, eavesdropper can be easily identified, smaller lens needs the user to come closer to the window
	* Mohammad will upload a revised version where graphics are rendered correctly
5. Nikola Serafimovski (PureLiFi) presented a multi-author contribution in doc. 1631r1 co-authored with Tuncer Baykas (Mediopol University).
	* **1st Use case is Ceiling indoor LC**
	* **2**.5 to 10 m, 200 Mbps to 1 Gbit/s
	* Combined use with 802.11ax, ay
	* **2nd UC is Close proximity LC**
	* **3rd UC is V2V**
	* 1m to 50 m, 1 to 50 Mbps
	* hybrid use with 802.11ax,ay
	* **4th UC is infrastructure to vehicle**
	* **5th use case is underwater communications**
	* 1 to 100 m, 1 to 50 Mbit/s
	* Volker asks how 802.11ah (RF) can be used underwater, should be clarified
	* It was added by the committee that this is not only niche application: divers networks, oil and petrol industry, underwater plants
6. Meeting recessed

**Tuesday, November 7, 2017, PM2 Session**

Attendance: around 50 people

1. Rui Yang (InterDigital) presented coauthored with Alphan Sahin (InterDigital) in doc. 1748/r0
	* Use case is Underwater Communications by using LC
	* Has unique advantages for short range communication underwater over exiting technologies, like acoustic communication and RF
	* 150-200 m in clear water, 50-75 m in ocean water, negligible multipath until operating at more than 1 Gbit/s, 450 nm for clear deep water, more towards green for costal water, solar radiation makes an impact

1. Volker Jungnickel (Fraunhofer HHI) presented a multi-author contribution in doc. 1710/r0.
	* Sang-kyu Lim (ETRI): why the wavelength range of infrared transmission / reception is limited.
	* Volker: it’s due to the low cost requirement. It requires different semiconductor technology on the receiver side otherwise. It may no longer be silicon. The requirement of low cost needs the photodiode to be silicon. It also depends on the scenario. For industrial cases, the cost may not be a serious concern. But for mass market product the cost is important.
	* Sang-kyu (ETRI): Which solution is more effective, VLC or IR?
	* Volker: IR emitter usually has higher efficiency than white LED. Sensitivity curve of silicon photodiode is at maximal in IR range. Experiments show IR has better performance. It needs to be discussed.
	* Gaurav Patwardhan (HPE) ask for a clarification of mobility issue.
	* Volker: It is a good idea to integrate LC and radio technologies. For example backhaul benefits from parallel usage of VLC and RF to achieve diversity. For industrial use cases, liability of the link is crucial. As LC is directional it can be interrupted. RF is a good way for the fallback.
	* Jeff Jones (Qorvo) questioned the number of users per access point.
	* Volker: the number of users per access point is small because the coverage area of one access point is limited to a few meters. In a robot cell there may be two or three robots working under the same access point.
	* Nikola: one of the requirement from Liberty Global is to have more user density. I think it depends on the use case. What we see so far, the required density is on the order of ten or fifteen.
2. Andrew Myles (Cisco) presented doc. 1661/r0.
	* LiFi can enable complementary indoor communications.
	* LiFi leverages LED lighting, lighting business is going to change.
	* Osama asks what the additional LC capability would cost for the lighting
	* Answer (Andrew): More, but if you could add value it is worthwhile.
	* Osama asks further how much: Answer is that cost is similar to Wi-Fi AP.
	* Li-Fi has to be more than a solution where RF is not allowed.
	* Can be used in nuclear power plants, which is RF-free area, main reason is for geo-positioning.
	* DoD security issues can be solved
	* Use cases where devices need wireless but no mobility, e.g. cameras placed in locations which are hard-to-reach
3. Nikola Serafimofski (pureLiFi) presented doc. 1694/r1 co-authored by Harald Haas and Eric Yin (both University of Edinburgh).
	* Security issues of LC
	* Jamming a LC network is difficult, needs a lot of power, users can move to another light, …
	* What is Secrecy Capacity is max(0, R1-R2), rate is smaller than secrecy capacity
	* No eavesdropping from outside the room, LOS eavesdroppers are easily identified
	* If you move by 1 m, you have a dramatic loss of SNR at the eavesdropper
	* Question was that 1 photon is enough to detect the signal. Answer is that the rate of change needs to be detected, needs more photons, look at avalanche photodiode, it needs a minimum amount to detect the data signal
	* Multiple lights can provide cooperation and improve security, precoding can increase the secrecy rate
	* Angle diversity transmitter, Flying-eye design is like passive beamforming in mm-wave
	* Can be made finer and the finer the beam is the more secure is the link
4. Jiamin Chen (Huawei) presents 1743/r0 which is coauthored by several colleagues on usage models for LC.
	* Summarizes previously proposed use cases and provides a baseline for further discussion
	* General advantages of LC are summarized, see contribution
	* 4 use case categories are proposed (EMI sensitive area, positioning and navigation, localized information service, LC internet/intranet access)
	* Difference between use case and usage model, contains 1) pre-conditions, 2) environment, 3) application, 4) traffic conditions, 5) use case
	* Model 1 EMI sensitive environment: a) Hospital, b) nuclear plant, c) industrial robot, d) underground mining
	* Usage models have been worked out and presented for all categories, refer to the presentation.
	* Volker asks what is the purpose of the provided document, what is the methodology behind? Answer is that such document is required for task group, more general KPIs can be derived from such document, very initial draft is provided here that will be extended based on further available contributions from November meeting.
5. Nikola Serafimofski (pureLiFi) presents doc. 1663/r0 which was jointly prepared with Martin Ziegel (Zumtobel).
	* LC should enable the lighting industry to continue to satisfy key requirements for lighting
	* LC should not breach existing regulation for health & safety and general device regulation
	* LC should complement existing RF technologies
	* LC should support digital dimming of the light source.
	* There was a discussion on the dimming initiated by Osama. Volker also mentioned that if this is integrated into the PHY/MAC this leads to a very complicated specification, for example see 802.15.7-2011. TG13 in 802.15 has just recently reached a reduction of the related complexity by clearly separating dimming and communication capabilities and essentially handling dimming now below the PHY. 802.11 could leverage from previous work in 802.15 on this topic.