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MOBILE FREE SPACE OPTICAL COMMUNICATION'S SYSTEM DESIGN AND ITS PROCESS

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ABSTRACT

This short introduction discusses the key motivation for this special issue of the Journal of Optical Communications and Networking that focuses on the area of optical networking for 5G mobile and wireless commmnications. It summarizes the key topics addressed in the in- vited and contributed articles that were selected following the open call and provides a synopsis of their main findings and conclusions.Free-space optical communication (FSO) The system is designed for mounting on mobile platforms, with effective range of at least 50 meters. Light- Emitting Diodes (LEDs) and Laser diodes (LDs) are used in the transmitter for comparison for their relative performance in the system. The receiver features a beam splitter that feeds part of the data link optical signal to a quadrant photodetector and controls a tracking/stabilization system using microcontroller. Since almost all commercial FSO systems are mounted on fixed positions such as buildings, the paper explores the possibility and challenges of designing a FSO system for a mobile system such as remotely operated-vehicles or between ships.

Mobile Free-space Optical Communication (MFSOC) offers highly directional, high bandwidth communication channels between two devices. Its links can provide fiber-like data rates over short distances with low probability of interception . It also provides last mile solutions in many of today static communication system substituting wired or microwave system . Recently, satellite system has begun using FSO as its communication channel thus employs a mobile system . However, there are currently very little development on cheap, short range, mobile FSO system, for use between ships, ground vehicles and aircrafts . It means the system has to be cheaper, less massive and less fragile than its counter parts in satellite systems. It is proposed to use Vertical Cavity Emitting Lasers (VCSELs) transmitters to design a low the cost of FSO system . In our paper, we also investigate difference light source for the FSO system to reduce the system cost and make it mobile.

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INTRODUCTION

Declarative React views are declarative. What this really means is that you, as a programmer, don't have to worry about managing the effect of changes in the view's state or the data. In other words, you don't worry about transitions or mutations in the DOM caused by changes to the view's state. How does this work? A React component declares how the view looks like, given the data. When the data changes, if you are used to the jQuery way of doing things, you'd typically do some DOM manipulation. Not in React. You just don't do anything! The React library figures out how the new view looks, and just applies the changes between the old view and the new view. This makes the views consistent, predictable, easier to maintain, and simpler to understand. Won't this be too slow? Won't it cause the entire screen to be refreshed on every data change? Well, React takes care of this using its virtual DOM technology. You declare how the view looks, not in the form of HTML or a DOM, but in the form of a virtual representation, an in-memory data structure. React can compute the differences in the virtual DOM very efficiently, and can apply only these changes to the actual DOM. Compared to manual updates which do only the required DOM changes, this adds very little overhead because the algorithm to compute the differences in the virtual DOM has been optimized to the hilt.

Component-Based The fundamental building block of React is a component, which maintains its own state and renders itself.

EXPERIMENTAL SETUP

We developed a 10MHz free-space optical communication with low power, light weight and low cost. This system is designed with the goal of mounting on mobile platforms, with effective range of 50 meters, with full tracking and stabilization system using servos. Since the system is in a confined space, the battery power has to be used as its power source. This puts a limited on power consumption and weight of our system. Our communication module design consumes approximately 600mW of total power and outputs 15mW of optical power, which consumes relative less power compared to the existing systems described above. The receiver features have a beam splitter that feeds the part of the optical data link signal to a quadrant photodetector in order to control the tracking and stabilization system. A microcontroller is used for servo controls based on the sensor information of the quadrant diodes. Since the signal is weakened by the beam splitter, we need to replace it with a more sensitivity thus more expensive photodiode or suffer a penalty on the maximum range. Since the 50 meter range considered in this system is relatively short, a cheap photodiode is used. Our system achieves a 10Mbps of digital bandwidth. However the bandwidth is scalable without escalation in power

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consumption and weight, but development cost will be substantially higher for the scope of this project, but this option remains for future development. Both LED and Laser devices are designed, measured, and compared for their performance in the optical free space communication system.

The proposed mobile free space optical communication system is shown in Fig. 1. It is setup as a full duplex optical connection between two computer systems. The computer connects to the optical system via base-10 Ethernet; the optical system then encodes the digital data into an optical beam. At the receiver end, a beam splitter is used to split the beam into two, one beam enters the communication system that coverts the optical data back into electrical data, and the other beam enters optical position detector to control the tracking system. As shown in Fig. 2 and Fig 3, since the optical beam is used for the tracking system as well as the communication system for the signal integrity purposes, a constant light beam must exist between two systems. Thus when data is present on the Ethernet line, the data will be allowed to the transmitter, otherwise a 1MHz signal integrity signal integrity signal will be sent. On the receiving end, the 1MHz signal will be filtered out. Also for the purpose of this experiment, laser diode and LED light sources are compared. Fig. 4 is the block diagram of the transmitter and the receiver design. The transmitter consists of a differential amplifier that amplifies the signal from the digital line drivers, and then passes into a wave shaper which improves rise time. A current amplifier creates enough current to drive the laser and LED diodes. The receiver consists of a reverse biased photodiode that feeds into a differentiator of the pre-amplifier instead of a Schmitt trigger for wave shaping.

The preliminary design consists of a two-axis system to be placed on both the receiver and transmitter, as both systems are placed side by side in the same package. A servo motor that drives the base allowing for 360 degrees rotational tracking adjustment, and another servo motor that controls the tilt with +/- 30 degrees. This system is controlled by a quadrant photodetector in order to keep the cost down. In more robust systems, a true X-Y position sensing photodetector is recommended. The sensor information is then fed into a microcontroller that controls the servo motors to keep the receiver and transmitter aligned. Since the transmitter and receiver are facing the same direction, the tracking system is only necessary on the receiver end. Aligning the receiver of unit B to the transmitter of unit A will automatically place the transmitter of unit B toward the receiver of unit A. Since both rotation and tilt adjust are present on both units, it should account for all reasonable relative movements. For the system used in range of 1 meter to 50 meters, an adjustable lens system is not necessary. In more robust systems, an auto focusing lens similar to those used in cameras could be used. The tacking system is built and integrated with

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the communication system. The entire system with transmitter, receiver, microcontroller and tracking system, is expected to consume less than 10 watts of power and weight less than 2 pounds, which is far less power and less weigh than the current FSO systems such as Canobeam and other commercial FSO systems. The use of servos means that moving portions of the system must weigh as little as possible to enhance mechanical performance. Thus only the final stages of the receiver and transmitter as well as the beam splitter are present on the tracking housing, with all other systems mounted below. To reduce the project cost, the testing system only has one tracking unit, while the other unit is manually adjusted. [3] discussed about Improved Particle Swarm Optimization. The fuzzy filter based on particle swarm optimization is used to remove the high density image impulse noise, which occur during the transmission, data acquisition and processing. The proposed system has a fuzzy filter which has the parallel fuzzy inference mechanism, fuzzy mean process, and a fuzzy composition process. In particular, by using no-reference Q metric, the particle swarm optimization learning is sufficient to optimize the parameter necessitated by the particle swarm optimization based fuzzy filter, therefore the proposed fuzzy filter can cope with particle situation where the assumption of existence of "ground-truth" reference does not hold. The merging of the particle swarm optimization with the fuzzy filter helps to build an auto tuning mechanism for the fuzzy filter without any prior knowledge regarding the noise and the true image. Thus the reference measures are not need for removing the noise and in restoring the image. The final output image (Restored image) confirm that the fuzzy filter based on particle swarm optimization attain the excellent quality of restored images in term of peak signal-to-noise ratio, mean absolute error and mean square error even when the noise rate is above 0.5 and without having any reference measures.

First generation of ICT-based services on mobile phones For about two years, the use of mobile phones as a platform to deliver services to underprivileged populations and rural communities has been experienced all over the Developing World, particularly in India and some countries of Africa. Many stories have demonstrated the ability for

SMS Applications Today, SMS applications are the most common way used in the Developing World to provide eServices. People, knowing the phone number associated with the service, send an SMS to this number with appropriate keywords, and get back the answer by SMS. Sometimes, when there is no interaction needed (e.g. sending weather forecast), it is just a broadcast of SMS messages to people subscribed to the service. The reasons of the success of this technology are numerous: Ease of use for users: using SMS capability of a mobile phone is very easy and natural

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for users. People are used to use text-messaging for people-to-people communications, and so using the same mechanism to reach a service is easy. Availability on all phones: All mobile phones are able to send and receive SMS. Low network requirements: SMS don't need high-bandwidth network, and GSM networks are sufficient to run services based on this technology. Low and predictable cost: Both with prepaid Simcard and subscription plans, one always knows how much the sending of SMS costs, and it is usually inexpensive. • Free push mechanism: Except in the USA, the reception of SMS is free. So receiving data, even if it is split over multiple messages, is free to users.

However, there are also some weaknesses associated with this way of providing eServices. These limitations can be classified in two sets, those inherent with the use of textual information for both the input and the rendering, and those specific to the SMS technology. Concerning the use of textual information, there are 3 major problems: • Illiteracy of populations: In order to use SMS, people have to be able to write and read. This is a big problem when the aim is to reach populations where there is a high level of illiteracy. That said, while this would be a problem if we want to reach each individual, it could be of less importance in the case of community-shared phones, which is a very usual case in the Developing World (a well-known example is the phone-Ladies in Bangladesh.

While SMS-applications are clearly the most used techniques to offer eServices today, we think that this is due to the lack of better solutions. Given the mentioned intrinsic weaknesses, we can't see how it could be possible to deploy a big numbers of services at a large scale, targeting a population of millions of people.

Voice Applications Unlike other types of applications, Voice applications don't have any specific module on the mobile phone. People are just placing a traditional phone call at a specific phone number to reach the voice platform from which the service is accessible. From there, navigation through the application is done either by voice input (the user speaks to the application) or by pressing the phone keypads. This type of applications has some specific strengths: Easy to use for illiterate people: the usage of Voice applications doesn't require the ability to read or write

Easy input mechanism: The voice of the user or just pressing one key of the keypad are the most easiest and natural way of interacting with an application. Low and predictable cost: the cost of the usage of the applications is the cost of the phone call, based on the length of the call. So people know exactly how much they are paying for accessing a service, and voice service is the cheapest service. Low network requirements: Given that the network is just used for its voice service, they are no requirement on the characteristics of the network. Operator Independence: As far as

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the operator is allowing its user to call any number in the world, all voice platforms in the world are accessible from any phone. Standardized application development: There are now easy and standardized ways to develop Voice applications based on VoiceXMLtechnologies , which would work on all Voice platforms complying to this standard. This family of markup languages takes also advantage of the power of the Web, and could be used to provide Web access to people not being able to read and write. Despite these specific features, there are also issues that may delay the adoption of voice technologies in a near future: Discoverability of services: like for SMS, people who are not aware of existing services have no way to find them, and to find the right phone number to call. However, this problem is of less importance in the case of Voice applications, as with the power of technologies like VoiceXML and the Web, it is possible to consider deploying portal applications: People would have just to know the phone number of the Voice portal from which they could access a list of services that could be easily/automatically updated. Cost of application hosting: While the development of voice applications is easy and affordable, the hosting is extremely expensive. Setting a voice platform on which run the application, with a good voice recognition software and a good speech synthesis engine is very expensive. It is, of course, possible to use one of the existing hosting services in the World, but it doesn't make too much sense in the context of Developing Countries, where users would have to make expensive international phone calls to reach the service. Such platforms should exist at the country level, but still requires heavy investments. Availabilities of languages: most of the power of Voice applications is coming from the ability to process and generate natural languages. Unfortunately, as of today, speech recognition has some success in the most used languages (English, Spanish, French…) but is not available for other languages. It is the same for speech synthesis. Even if there are ongoing work on internationalizing SSML , we are not at a stage where this is a reality now. • Hard authoring and design: While it is quite simple to develop basic, keypad-driven Voice applications, using the full capabilities of speech recognition is another degree of complexity. Writing grammars and complex interactions needs good experience in usability to avoid bad user experiences. Understanding that users are not "visualizing" the content is one of the key difficulty in voice application design.

Eventually, Voice applications clearly have the right potential to help in some specific areas, particularly to tackle the literacy problem. However, particularly in the speech synthesis domain, further research is necessary before considering voice technologies as the recommended way to provide eServices. Even if the technology was appropriate, such applications would require investment at a country level, and the complexity of application development

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will still be a barrier to enable local people. Like for SMS, Voice applications are a potential solution in some specific projects, but we don't believe that it has the potential to be the right solution to provide a huge number of services all around the World.

While all the existing success stories demonstrate the potential of mobile phones to be the most promising platform to deliver services to rural and under-privileged populations of Developing Countries, we doubt that the current technologies would allow a large scale development and deployment of applications. Moving from "islands" of successes as it is today, to a World where thousands of services are available, usable and useful for under-privileged populations is a huge challenge which could hardly be tackled by SMS or Voice applications. We believe that only the switch to Web technologies will allow this transition, and we will present, in the next section, the roots and rationale of this view.

THE NEXT GENERATION OF MOBILE APPLICATIONS: THE MOBILE WEB

The Web is clearly an incredible space of communications and exchange as well as an endless source of information. For that reason, W3C, the standardization organisation for all Web core technologies , has a mission to work toward Universal Web Access (the Web for Everyone, at Anytime, from Everything). Enabling Web access from mobile phones is part of this mission, and is the specific work item of the W3C Mobile Web Initiative . However, providing access to the Web may not be a goal by itself for rural communities. The aim is to provide services to populations using the power of the Web as the support for facilitating the development and the deployment. Among its numerous features, the Web has indeed some specific strengths in this context: • Discoverabilities of services: Search engines and portals are the natural existing ways to discover existing and new services. Given the state of the Web today, their scalability has been largely demonstrated. • Operator Independence: As far as the operator is providing a data service plan with full Web access, there is no interoperability problem. • Easy development of services: Using e.g. standardized interoperable markup languages like HTML, Forms, CSS to create content, using programming languages like PHP, ASP, Perl, Python, and databases to manage information is very easy due to free availabilities and a huge amount of resources. This is probably one of the strongest argument that explain the growth speed of the Web, Allowing anybody with minimal knowledge to create Web resources ensure the availability of a huge number of information. Where SMS and Voice applications require heavy and expensive platforms, specific knowledge and skills, developing Web content would be far more accessible, and the effort required to empower local people will be far smaller. • Easy hosting and deployment: Once the

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application is developed with above-mentioned tools and technologies, there are thousands of very inexpensive / free hosting services over the Web. Here again, where SMS and voice platforms requires investment at a global level, it is very easy for anybody to host his applications and content. Moreover, no further advertisement would be required to make this content available, thanks to search engine. • Good user interface: It is very easy to create simple-to-use but complex interaction between the user and the application thanks to e.g. HTML forms. As previously presented, making usable voice applications is a real challenge, and the limited capabilities of SMS do not allow multi-cycle interactions.

These specific strengths let us think that Web Technologies are the most appropriate way for future large scale, low-cost development, deployment and availabilities of ICT-based services on mobile phones. However, there are very few success stories today about Web usage on mobile phones in Developing Countries. This is due to the existing challenges requiring appropriate adaptation of

existing standards, and new ways of developing content and applications. We will explore in the next section of the paper what are these challenges, and which actions could be engaged to tackle them.

CHALLENGES OF THE MOBILE WEB FOR DEVELOPMENT

The strengths of the Web are obvious, and its incredible success in the last ten or twelve years illustrate them. The recent take-off of Mobile Web access in the Developed World is also an evidence of the importance of Web access on mobile phones. As underlined in the section 2 of this paper, the potential of the mobile platform in development is also clear. The question is to know if these two aspects fit together, and if the Mobile Web is a promising opportunity for Developing Countries. Lots of people are indeed doubtful on the potential of the Mobile Web to be a solution to improve people lives, and leverage development of rural communities . We will review in the following the usual problems people are considering.

Cost of data access Lots of people think that data service and web-capable handsets are very expensive, and rural communities would never be able to afford them for Web browsing. This is true, if we consider only the cost of the access. The critical aspect is the return on investment. It is very unlikely that a crop producer in rural India would spend the required money to surf the Web for entertainment, because he would consider the money wasted, and not invested in his basic needs. At the opposite, if accessing a service to declare his new children costs him a day of salary, but the travel to the nearest office would require more than a day, then he would surely go for the online version. This specific aspect has been very well studied in the literature . Moreover, the overall model of the mobile telephony, concerning the voice service, is here to illustrate these theories. 4 or 5 years ago nobody would have bet that Developing Markets could be a business opportunities for Mobile players, and now they are considered as the most beneficial ones. All the models which worked for the voice service (community shared access, phone ladies model) are able to work for data access too. So the cost of data access should not be a problem only if valuable content and services are available to potential users.

Availability of high-capacity networks and high-end handsets If we look at how the Mobile Web has been evolving in Europe, US or Japan last 2 or 3 years, we can see that the trend is to aim at providing the same user experience as on a classical desktop machine. Device manufacturers, operators, browser makers… all mobile players are working in that direction. Given that Web content in 2007 are highly multimedia, with video, sound, picture and so on, high capacity networks and powerful devices are indeed required to access those. Are these requirements the same in our context? Probably not. One would not need sound and video, or color screen to provide useful services to community. And therefore, GSM should be perfectly ok to deliver quickly that kind of services. Again, the success of the SMS applications illustrates this aspect. Unfortunately, as of today, all the low-end devices, targeted at Emerging markets don't have a web browser. Such capability appears usually in the expensive devices. This is clearly a problem, and a potential limiting factor. But is it technically challenging or costly to provide basic browsing capabilities on low-end phones? We tend to think that it is not. Indeed, what is really required is at least a minimal browser being able to render xhtml basic, css mobile, and probably also a simple image format. Late 90's, all mobile phones had such minimal capabilities with the availability of WAP browser. It was not Web standards, but a specific markup (WML), but it was very close to xhtml-basic. So having a similar capacity today on all phones is not a hard thing to do, is not technically challenging, and does not require a very

powerful handset. The current lack of such a minimal browser is most probably due again to the lack of demand from users, because of the lack of useful content.

As we can see, the critical problem is to make useful content for rural communities, content that would help people in their daily lives, and allow them to get more income and afford the service. In the last part of this section, we will focus on defining what is a useful service or useful content.

3. RESULTS AND DISCUSSION

The available test area for the project is limited at 50 meters. Therefore it limits the maximum range for the data collection. For the duration of the entire range waveform recovered at our digital interface stage and differentiator stagnation remained very much the same near maximum amplitudes, while the preamp stage amplitude is different. Thus that data is collected to reflect system performance. The LED beam become extremely divergent after 10 meters as it can not be detected by the IR card, however, the receiver system can still detect the waveform transmitted at about 10 meters. At distances greater than that it become very difficult to locate the beam and detect data. Optics used for a LED flashlight is used for the LED beam system, which is not as delicate and expensive as the collimator used in the laser diode system. However, this experiment shows that due to its beam divergence, the LED light source can not be used for the mobile FSO device, if a beams liter/quadrant diode method is used. Fig 5 shows our analogy link performance (a) function generator output; (b) receiver's output at 10m for Laser Diode (c) receiver's output at 50m for Laser Diode; and (d) receiver's output at 10m for LED. The maximum distance for LED is only 10m for our experiment. In the scenario where laser diode is used as the light source, the beam remained confined even at 50 meters if the collimator is adjusted correctly. Thus makes it more suitable for beams splitter/quadrant diode method for beam tracking. The preamp output amplitude shows a decreasing trend over distance, this is a function of both atmospheric absorption and beam divergence. A way to adjust the collimator at longer distances would partially eliminate the beam divergence factor. Also the preamp output shows a triangle like waveform output, this is caused by the capacitor used to block DC current to the differentiator, and this is eliminated by the Schmitt trigger. The final performance of the signal versus distance is shown in Fig. 6 for LD system. The data clear indicate the 50m transmitter capability of our mobile FSO system, which is limited by the testing space.

CONCLUSION

The possibility and challenges of designing a mobile FSO system for remotely operated platforms. Therefore low power and light weight are essential qualities. The paper demonstrates a 10MHz mobile FSO communication with low power consumption, light weight and low cost. The system is mounted on a mobile platform with the battery power. We realize arbitrary signal transfer at 50 meters, design the tracking system using beam splitting technique, and successfully interfaced to Ethernet for a packet transmission. LDs and light-emitting diodes (LEDs) are used respectively in the transmitter design and be compared on the system performance. The LD transmitter consumes 600mW of total power, and outputs 15mW of optical power, which is better than that of the LED-based system.

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