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Event-Based Mobile Social Networks: Services, Technologies, and Applications

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ABSTRACT Event-based mobile social networks (MSNs) are a special type of MSN that has an immanently temporal common feature, which allows any smart phone user to create events to share group messaging, locations, photos, and insights among participants. The emergence of Internet of Things and event-based social applications integrated with context-awareness ability can be helpful in planning and organizing social events like meetings, conferences, and tradeshows. This paper first provides review of the event-based social networks and the basic principles and architecture of event-based MSNs. Next, event-based MSNs with smartphone contained technology elements, such as context-aware mobility and multimedia sharing, are presented. By combining the feature of context-aware mobility with multimedia sharing in event-based MSNs, event organizers, and planners with the service providers optimize their capability to recognize value for the multimedia services they deliver. The unique features of the current event-based MSNs give rise to the major technology trends to watch for designing applications. These mobile applications and their main features are described. At the end, discussions on the evaluation of the event-based mobile applications based on their main features are presented. Some open research issues and challenges in this important area of research are also outlined.

INDEX TERMS Mobile application, mobile social networks, mobile event guide, context-awareness, mobility, multimedia.

I. INTRODUCTION

The remarkable development of social networking environment and communication technologies has taken our society one step closer to ubiquitous communication whereby numerous devices can be connected to the internet anytime [1]. Mobile Internet of Things (IoT) [2], [3] is expected to reinforce the development and use of target social applications. For event-based activities there are recently developed online event-based applications such as Eventbrite, Meetup, Plancast and so on. Using these applications, users may recommend social events, such as casual gathering (e.g. bowling, movie, bike ride, and dinner party) and official activities (e.g. conferences, courses and meetings). On top of supporting representative online social networking features (e.g. posting and sharing comments, videos and photos), these event-based applications also promote offline face-to-face social communications. [4]. The origin of social networks lies in the early 1990s when they were simple means of communication between people over the internet, such as forums, discussion groups, professional associations or other places where people could exchange ideas [5]. The tremendously increased interest in social networking and smartphones results in the emergence of Mobile Social Networks. Mobile Social Networks (MSNs) combines techniques in social science and wireless communications for mobile networking [6]. The MSN can be considered as variety of services such as data management exploiting the social relationship among mobile users.

Activities that are considered appropriate on social occasions are occurring all over the world as an important part of life and they are named as social events. These kinds of events (meetings, conferences, tradeshows, festivals, entertainment, and so on) have been organized and planned using paper-based program guides. We believe that it has not been more

than five years since event planners and organizers started to use mobile devices as a replacement for the paper-based program guide. The rapid innovation and user adoption of sophisticated smartphone technology has certainly played a hand in the change. Yet, despite the emergence of mobile technology, the majority of events still use paper-based event guides and programs - this is about to change [7]. From these social events, large academic conferences/workshops attract researchers from academia and industry from all over the world [8]. Many such conferences/workshops have several tracks and sessions that runs parallel, or a number of poster papers presented at the same time. Therefore, it's essential that participants or attendees are able to communicate with each other to enable instantaneous information exchange by using event-based applications running on mobile phones (event-based MSNs).

Event-based social application continues to progress with technology products becoming cheaper, better, and easier to use. Innovation is sparkling with new options and features. According to MPI's FutureWatch 2011 Survey [9] recent data, more than 80% of meeting professionals are using smartphones and other mobile devices in their careers. Taking this high adoption into account, yet relatively few have used mobile applications for their own meetings. Nowadays, we are seeing a very fast adoption of mobile applications for event-based social activities especially for meetings and conferences. Event-based MSNs will bring many tangible benefits to event planners, organizers, exhibitors and attendees, i.e., real-time distribution and access to all conference information, improved way-finding through interactive maps, floor plans and location-based services, alerts/conference messaging/updates, better analytics, enhanced attendee and exhibitor experiences and many more. Recently, several researchers, academicians and developers have devoted substantial effort in designing and developing diverse event-based MSN applications [11]. Consequently, numerous mobile applications have gradually been designed and developed for event-based social activities.

The purpose of this paper is to review event-based MSN services, technologies and applications and it covers four objectives: First, to present an overview of event-based MSNs with their principles and architecture [10]–[28]; second, to explore an event-based MSN technology elements such as context-aware mobility and multimedia sharing [29]–[81]; third, to present commonly used and available mobile applications for meeting, conferences and tradeshows; and fourth, to provide a discussion of these applications based on their main features and outline open issues for future research directions in the area. A number of researches have been conducted for presenting approaches and social networking applications for social events. However, to the best of our knowledge, none of the existing work surveyed event-based MSNs in detail.

The remainder of the paper is structured as follows: Event-based MSNs overview and the related basic principles and architectures are presented in Section II. Section III explores event-based MSN technology elements such as context-aware mobility and multimedia sharing. Section IV introduces several mobile applications or research projects in MSN for meeting, conferences, and tradeshows. Section V discusses some mobile event-based applications based on the main features and major technology trends to watch for the future application development. Section VI outlines some open issues and challenges. Finally, the paper closes in Section VII by providing concluding remarks.

II. EVENT-BASED SOCIAL NETWORKS

In an informal manner, an event is a piece of information that is valid only for a short period of time. Social software manifests itself by offering multiple users the ability to interact online through media of different forms. Many researchers [12]–[17] have done a lot on web based social event applications starting from micro blogging to using twitter on smartphones for organizing conferences and workshops that leads to the current event-based social networking development. Defining the management system of an event, for example; in conference management system, users with different roles (i.e. authors, reviewers, chairs, etc.) have access to specific tasks in a predefined time slot depending on the schedule. However, the above research works are concerned about the complete web based event social network and interactions of different roles in a conference contribution management, but they ignore studying the event-based mobile connections, managements and related technologies. The remainder of this section details on event-based MSNs, the principles and architecture of this network applications.

A. EVENT-BASED MSNS

Event-based online applications have provided suitable online platforms for users to create, publish, and manage social activities. According to Liu *et al.* [4], Fig. 1 depicts Meetup and Plancast as two event-based social network examples. Meetup facilitates users to have offline social meetings by posting and sharing comments as well as photos with other users of the application. Besides, it allows users to search and join to social event groups with a common interest (''Dalian downtown area photographers'', ''DUT street walkers'') taking place in two usually opposite directions (bi-directional). Plancast allows users to discover, recommend,

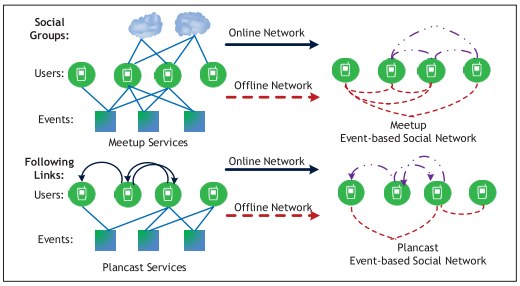

FIGURE 1. Event-based social network examples: Meetup and Plancast.

and celebrate social events of common interest by "following" other users' activity calendars in a uni-directional subscription. The online as well as the offline social communications together describe an event-based social networking as displayed on Fig. 1. Whisper [10] is implemented for creating, sharing and finding social events over mobile phones. It differs from these event-based sites in that it emphases on supporting ad-hoc near-term social activities.

Event-based MSNs are a category of dynamic social networks having a shared feature that the events in the social network are immanently temporal. In another word, there is a time stamp for all the events to specify when the events have occurred [18], [19]. Therefore, nodes and events representation, relationship between the nodes and events, and construction of an event-based social network for an efficient detection and discovery of important nodes become an essential issue [20]. When constructing an event-based MSNs, most of the existing social network approaches such as the work in [21], only deals with actors as nodes in a social network. However, Yuan *et al.* [20] deals with two forms of nodes in the network (actors and events) to make the model carry more information. Fig. 2 shows a simple mobile event-based social network that deal with two forms of nodes, actor-nodes and event-nodes, and two forms of arcs, link between actor-node and event-node and link between two event-nodes.

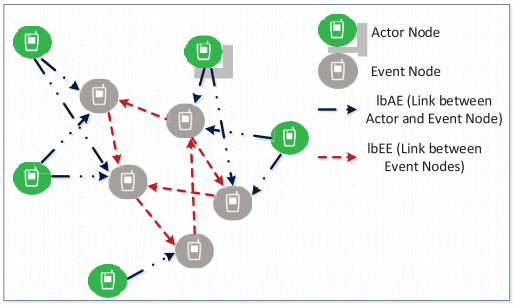

FIGURE 2. Simple example of Nodes and Events with their connection mode in an event-based MSN.

One significant area of investigation on event-based mobile social services concerns augmented group interaction and the behavior of groups in a discussion. Typically, in group communication contexts, spoken participation is viewed as the primary or dominant interaction medium, one that is often the target of modification as in, for example, Second Messenger [22] or Meeting Mediator [23]. Tin Can [24] system placed emphasis on the combinatory possibilities of text-based and verbal participation in a co-located group communication environment. It also focuses on enhancing the performative space of group interaction.

B. PRINCIPLES AND ARCHITECTURE OF EVENT-BASED MSNs

Due to the emergence of studies on mobile social activities, the capacity to build systems that adapt the delivered information and knowledge to meet the requirements of users in smart environments has attracted quite a bit of attention. The primary objective is to develop the technology and improve the interaction of user-system quality in such smart environments [25], [26]. For event-based social activity planners and organizers that encompassed the generation of event-based mobile applications, the experiences were a major step forward for the industry in terms of replacing paper, increasing efficiencies, and reducing costs and the impact on the environment. The user experience, however, was limited to standard, template-style formats with basic, featureless presentation of content [27]. While the applications helped to replace the paper-based guide, they were not designed to encounter the primary objectives of today's event-based activity planners and organizers.

Managing an event for a smart community can be a frustrating matter for all planners, organizers and attendees. However, technological advances in wireless networks and the advent of new mobile devices have made possible the development of mobile applications that can successfully support all parties; mobile applications are easily accessible through a smart device and the user can effortlessly upload or retrieve any relevant information [28]. Former event-based mobile applications typically provide few opportunities for event branding. Because of their basic template style, branding may be limited to a simple splash page when the application launches or a banner at the top of the menu page. The other pages in the application typically include colorless, featureless lists of speakers, attendees and schedules. The experience is unappealing and implies that the attendee is only interested in the value of the application and only basic, essential information. The current and new event-based mobile applications are fully influencing the power that exists in the palms of virtually every business person in the world [27]. Like the evolution of the Web, to increase engagement, event-based mobile applications must also progress.

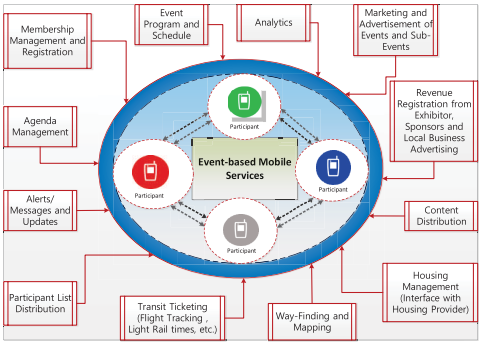

FIGURE 3. Event-based mobile applications human-centered interface surrounded by the main features.

The smartphone has become a crucial tool in the hands of the event attendee. Related technology and service motivating these devices has also improved, making it possible to develop customized applications. The focus of event-based mobile service is about creating a more memorable involvement and increasing engagement in the event. As shown in Fig. 3 what

is critical to event-based mobile applications is a human-centered interface that is branded, easy to use, surrounded by the main features and customizable. Modern mobile technology allows for high color resolution and graphics and enhanced user interactivity. In addition, from the architecture figure, back-end metrics can help meeting planners to understand how the application is being used and what features are popular amongst attendees. With these capabilities and knowledge, event-based mobile applications can be designed to meet the needs and wants of attendees, extending and improving the experience from one year to the next.

Event-based services could be provided to the community using the framework in Fig. 4. An event application server includes a mechanism for initiating the participant or the organizer to start the application, to collect data throughout the application period, and then to stop the application. The event application server develops its participant list from a membership management and registration handler. Membership management and registration handler includes the participant and application data for download to the participant device, and a means to create the event community and to communicate information about the participating user community to the event application server. On the other hand, an application store provides the actual application for the participant device. This application would be downloaded to the participating community device via the membership management and registration handler. Alternatively, this could be downloaded through a direct interface between the participant device and the application store. This application relies on the fact that the participants' smart devices have precise timing that provides alerts or updates to the participant about the coming event. This framework could be used to create event-based mobile social activities, where participants gather at some venue, and each participant's smart device takes the part of all the services.

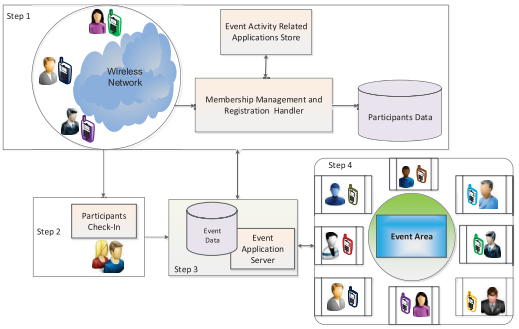

FIGURE 4. Event-based MSNs framework through the processes of registering for an event, arriving at the venue of the event, adjusting all the requirements, beginning the event participation and concluding the activity in the event.

To generalize the aim of our principles and architecture for event-based MSNs based on Fig. 3 and Fig. 4, is to provide a better intellection on the newly emerging event-based mobile applications through exploring their design feature and framework. Furthermore, the principles and architecture proposed for social events ought be able to function together within no adverse interactions occurring between the main features and the framework. Therefore, an in-depth evaluation and analysis will play an important role to understand the true benefits of event-based MSNs. Presently, event-based MSN is a new area to be explored in networking research. On the other hand, design attention must be considered so that the current technology itself doesn't limit the emergence of new application solutions. These new event-based mobile application solutions should be constantly evaluated based on the main features shown in Fig. 3.

III. EVENT-BASED MOBILE SOCIAL NETWORKING TECHNOLOGIES

The usage of smartphones for event-based social networks also called event-based MSNs. It is one example that combines the elements such as context-aware mobility and multimedia sharing. The mobility aspect of event-based social networks demonstrates that multimedia is no longer bound by time and space that can be used in any context. Technology endures to progress in this way as it develops more user driven and less regulated to schedules and locations. The smartphone also enhances event-based social networks by increased levels of sharing interactive multimedia. The event participants' role shifts from a passive receiver to an active contributor. It is this aspect of sharing multimedia when integrated with the context-aware mobility facet that makes event-based services actively productive.

Mobilizing multimedia comprises of capturing, storing, managing, distributing, and securing all forms of data (i.e. text, audio, video) according to the standards and guidelines notified by event organizers or planners and content vendors, accounting for several services or features used by participants. Making the mobile multimedia sharing experience interactive allows the participant to make enhanced manipulations on the data that is pertinent to him/her and the event community. By integrating the features of mobility with multimedia sharing in event-based social networks, event organizers and planners with service providers optimize their capability to recognize value for the multimedia services they offer; an increasing consumption by the participants leads to an increased content revenue and event advertisement sponsorship. Based on the above mentioned points discussing technology elements such as context-aware mobility and multimedia sharing are very important in the notion of event-based MSNs.

A. CONTEXT-AWARE MOBILITY

Context awareness is a property of mobile devices and deals with adaptation of computing mechanisms to the current context of users. Capturing user context is an interesting research field, and several capturing approaches have been proposed in the past [29]–[31]. For example, context has been studied in areas such as user location [32]. Therefore, studying of user's collective mobility turn out to be one of the most essential aspects of social context-aware computing [33], [34].

Mobility patterns of users' device play an important role in a wide range of event-based mobile computing applications, such as data gathering, dissemination/forwarding, and content sharing. A great interest in mobility models has been under active research in the past few years and demonstrated by [35]–[40] including for very specific situations like conference environments. Several times, rather than moving individually people tend to move in groups. For example, participants attending a conference/meeting or students attending lectures. However, such groups may change their movement behavior dynamically or frequently and of different strengths. People may stay longer among several groups at the same time or even in different groups at different times. Therefore, tracing real user movements' behavior can be quite heterogeneous and challenging. In order to address such challenges, numerous human mobility models have been proposed in recent years [41]–[48].

Among the existing models, we focus on nomadic community and reference point group mobility model because they fit for modeling event-based social applications. Nomadic Community Mobility Model [49] was created with an inspiration from the movement pattern of a member of group of people who have no fixed home, known as nomadic societies. In this category of mobility model, nodes are moving in a random manner around the same point until the reference point changes the movement; all nodes move from their current locations to the new reference point when the reference point moves. After the group settled at the new area, nodes continue moving randomly around the new reference point until the next movement or migration. This model appropriately fits to several scenarios such as conference, museum or a military operation. Gerla *et al.* [50] illustrated the use of reference point group mobility in a few representative cases. From all the cases, the interaction between exhibitors and attendees is modeled by convention scenario. In separate but networked rooms, a number of research groups give demos of their findings such as products or projects. While a number of attendees move from room to room in a group, they may stop in one room for some time and then move on to another. They may also just quickly pass through one room. This is referred to as the convention model.

To accurately predict user's location, it's crucial to distinguish and characterize mobility information of users in social events. Some existing researches such as [51]–[53], indicate that user mobility pattern is always characterized by the distribution of inter-contact time between users. However, they identified that the periodical association/re-affiliation within several communities as user mobility, and then examined the distribution of user *sojourn time* in communities instead. According to Du *et al.* [54], *Sojourn time* is defined as the user contact duration in a geo-community. This user contact duration remarks on user mobility and contact opportunity in MSNs. A user will be considered to forward data between geo-communities if its *average sojourn time* is shorter that allows it to move in the network frequently. The knowledge of user mobility information is essential to design data dissemination protocols which can be applied for the development of event-based applications in mobile wireless networks.

When we see the human mobility pattern on the other hand, almost all the anticipated event-based mobile applications are tightly coupled with humans' moving behaviors. The reason behind this logic is that wireless devices are generally carried by humans and are governed by their daily activities [55]–[58]. Human daily activities are regulated by their associated societal, cultural and environmental duties and very challenging to predict upon diversified locations and times. Moreover, it is still not clear how to postulate the complicated human mobility using the available mobility modeling, which, however, is essential to design the challenging and most important event-based mobile applications. The design of context-aware protocols requires understanding of human movement and pattern habits of their connectivity (frequency of meetings, frequency of visiting locations, average duration of contact, etc.). Therefore, there is challenge in studying human mobility and, specifically to event-based mobile applications. As discussed by Karamshuk *et al.* [59], the emerging main dimensions of people's movements are categorized as spatial, social and temporal axes. At the same time there were researchers who demonstrated their framework. For example: Xie *et al.* [60] designed a framework of individual mobility pattern mining. They demonstrated their framework by using real data set containing mobile phone data. Based on the result of an experiment conducted over real data, they have shown that their framework is efficient in discovering individual mobility patterns that can be used for wide applications.

In order to represent the space and time contexts in event-based mobile social services, the work in [61] adopted concept of *Point of Interests* (PoIs). PoIs are popular places in the navigation system, and users who are inside PoI can get events happening or being announced in the PoI. They assume that each user has a unique user id, a mobility profile with a series of contacts and PoI visits, a set of PoI events the user attended with time of the event, and a user influence lifetime TL to specify the time duration the user is willing to share the event with other users. In Fig. 5 there are four PoIs (denoted using rectangles) and twenty nodes/mobile users (denoted using

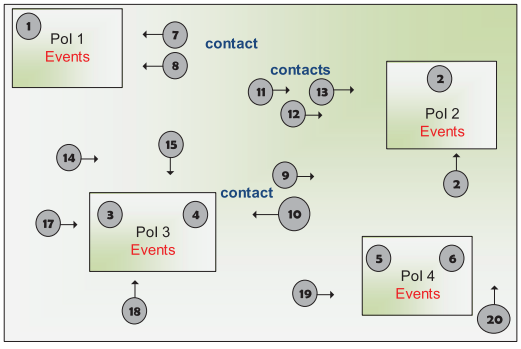

FIGURE 5. POIs and mobile users (participants in the same smart environment).

circles), where some users are moving outside PoIs (moving directions are represented using arrows). Mobile users may visit the PoIs at different times and can be attracted by the events during their stays inside the PoIs. Later, they can further influence other mobile users with the PoI events via their mobile devices when they meet other friends/users outside the PoIs any time before the expiration of their influence lifetimes. Once a user outside its PoI receives the event information, it may be further forwarded to other users. Therefore, the information influence is continued and connected in a *ripple carry fashion*.

Another strain of the user mobility in social events research work is focused on the detection and tracking of events. For this purpose, the deployment of wireless sensor networks in several application scenarios of event-based MSNs are being conducted to detect and track events of interest. Considering events location coverage, event can be either region events which cover a large area and have dynamic shapes or point events with an exact location constant shape [62], [63]. Yu *et al.* [62] have proposed a pipelined method for detecting and tracking events with dynamic event signatures called MEMS. While using a reasonable number of tracking robots, it has been known for its capability in detecting several events with low event count difference and high event membership similarity. Furthermore, it provides accurate event evolution history including event create, merge, split and destroy. Hubbell *et al.* [63] propose a general purpose event detection and tracking scheme called DRAGON. In the presence of event splits and merges, this algorithm is able to operate.

Most of the existing event detection approaches have one similar limitation that they focus on episodic and visual-only identification of some specific events. For example, the Sochi 2014 Olympic closing ceremony on February 23, 2014. The work by Ferrari *et al.* [64] instead suggests an approach to identify all the events in an automatic way. Several research studies have been recently conducted employing event detection methods and platforms. Moreover, in [65] the authors present mechanisms for detecting and discovering geo-social events and patterns based on *crowd moving behaviors*. The essential advantage of the work in [64] is that the presented approach is tested upon real dataset collected based on mobile phone usage.

B. MULTIMEDIA STREAMING

The new capabilities of mobile devices allow event-based MSN users to produce their own multimedia such as voice and video contents. Using the internet, peer-to-peer technologies also have emerged as a potential way to share contents [66]. For any wireless technology, mobile video delivery is a challenging application as it needs high bandwidth and has tight latency requirements. The work by [67] identified traffic load, contentions and collisions, interferences, and beaconing as key factors affecting video streaming performances. However, there are increasing efforts towards the convergence of heterogeneous access networks architecture standardization [68]. Developing multimedia applications over heterogeneous networks has been one of the main fields of research in the multimedia and networking communities. For example, the *IP Multimedia Subsystems* (IMS) platform [69] provides multimedia services based on heterogeneous wireless networks overlay architecture.

In-line with this technology development, it is essential to make new services and applications available for the users, thus facilitating them to share their content. Event-based mobile social services are becoming among one of these that offer such services to the user. The key aim of location-based multimedia (video, audio and text) sharing for mobile event-based applications is to offer event communities such as attendees of a conference with opportunity to listen audios and watch videos from the beginning anywhere anytime.

The exceptional features of the mobile usage setting can be used for enabling different usage situations for P2P systems. Kotilainen *et al.* [70], present PhotoJournal, a location-based system for media sharing between mobile P2P users. It allows users to form interactive multimedia journals that integrate multimedia objects. This system is supported by a positioning and information discovery middleware components. Cooperative Location-sensing System (CLS) [71], [72] and GPS [73] are the two technologies used for positioning. 7DS architecture [74], aids information discovery and sharing in a P2P manner. In this architecture, when intermittent connectivity to the Internet experiencing, users can cache data and share with neighbors. The drawback of 7DS lies on supporting only single-hop environment. Hence, a user only broadcasts the request to its neighbors to see if the data can be served from their caches.

A critical problem in wireless multi-content video broadcasting system with respect to heterogeneous characteristics is fairness among contents. To address this problem, the work in [75] proposed an approach of *context-aware utility fair streaming control scheme*. The mechanism aims at heterogeneous QoS video provision and approach of context-aware utility-fair sharing among video frames. Despite web-based video sharing is used in social events; most existing video sharing applications are not designed to be integrated and used for event-based MSNs. Besides, most of these video sharing applications were designed to be used on desk top computers via a web browser. In Multisilta *et al.*'s paper [76], they designed Mobile Video Experience (MoViE) which is applicable in learning environment especially with mobile

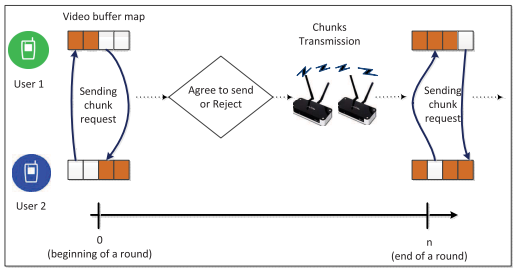

FIGURE 6. An example of users cooperation model in P2P social networks.

TABLE 1. Evaluation of event-based mobile applications and research projects based on the main features.

Mobile Applications and Research Projects	Environmental Friendly	Agenda and Membership Management	Messaging or Alerts	Attendee List and Schedule Distribution	Content Distribution	Marketing and Advertizement of Events	Analytics	Housing Management	Revenue Registration	Transit Ticketing	Way Finding and Mapping
Ungerboeck	✓	✓	✓	✓	✓	✓	-	-	-	-	-
GenieConnect	✓	✓	✓	✓	✓	✓	✓	-	-	-	✓
Grupio	✓	✓	✓	✓	✓	✓	-	-	-	-	-
CrowdCompass	✓	✓	✓	✓	✓	✓	-	-	✓	-	-
QuickMobile	✓	✓	✓	✓	✓	✓	-	✓	-	-	-
SeedLabs	✓	✓	✓	✓	✓	✓	-	✓	-	✓	✓
Pathable	✓	✓	✓	✓	✓	✓	-	-	-	✓	-
Zerista	✓	✓	✓	✓	✓	✓	-	-	-	-	-
EventMobi	✓	✓	✓	✓	✓	✓	-	-	-	-	-
FollowMe	✓	✓	✓	✓	✓	✓	✓	-	✓	-	-
Sherpa-Solutions	✓	✓	✓	✓	✓	✓	-	-	-	-	✓

devices. Fig. 6 displays an example of video live-streaming architecture for wireless social networks. An access point connected to the Internet provides the wireless network service. It demonstrates how two users cooperate with each other [77]: at the start of each round, every user sends a fragment of information that is used in many multimedia formats (known as *chunk*) requests to each other. After that, the supplier either answers with the requested *chunks* and starts transmission or discards the request. After one round, the same request- replying process is repetitive.

In recent years, smartphones allow capturing and sharing of video streams but further improvement is needed to get the different pieces to work properly particularly for academic or conference meetings. To reduce the existing technical problems, and to better realize the usage patterns of mobile phones for capturing and distributing videos, a lot of work and trials are needed to be done. A future mobile video related trial connected to large public events have to ensure the following as proposed by [78].

- seamless upload of offline voice/video contents
- flash technology playback
- mix of SIM cards (sponsored, own, own + sponsored)
- integration of video streaming/transfer to the camera application
- bearer sensitive live streaming with resolution and frame rate adaptation
- enhanced portal to facilitate video search

On the other hand, the work in [79] presented MobiSNA, a video application for mobile social networking that supports the exploration, sharing, and creation of video contents through social networks. It offers the user with an easy to use video content accessibility from mobile devices over wireless broadband networks. The authors indicated that MobiSNA can be improved in the following ways. Initially, one can explore the incorporation of MobiSNA with currently existing social network applications, such as Facebook and LinkedIn. Next, location-based services can also enhance the role of MobiSNA. Based on the collected location information of mobile devices, MobiSNA can deliver video content based on location of the user. Finally, MobiSNA can be designed to be integrated with applications such as social events, giving new awareness into domain applications.

Current and emerging systems let the above sharing services based on static personal preferences (e.g. popular social network sites, such as Facebook, Google+, LinkedIn, MySpace, etc.) and developed applications such as MoViE, MobiSNA and WhatNow [80]. However, these systems currently don't fully exploit the services. Ma *et al.*'s work [81] proposed a universal video sharing platform called MoViShare (Mobile Video Share). It provides anytime anywhere video publishing and browsing services for mobile devices, and aims to produce and maintain location-aware mobile social networks. To save the utilization of bandwidth and energy, it exploits *video abstraction technique*.

IV. MOBILE APPLICATIONS AND RESEARCH PROJECTS FOR MEETINGS, CONFERENCES AND TRADESHOWS

For reasons previously mentioned, there are several research activities working on mobile applications for social events. Due to smart devices portability, users can access online applications on their smart device using internet technologies such as WiFi or 3G cellular networks, anytime and anywhere. Initially, most online contents were available and accessible only from desktop computers, not from smart devices. Deploying and accessing online contents on smartphones is quite troublesome. To deal with these complications, most online contents can now be converted into formats appropriate for smart devices by using mobile web and native application approaches [82].

Fortunately, our selection of these few applications and research projects from plethora of options out there is those who have strong mobile components and many of them are

better-featured as shown in the evaluation table (Table I). When mobile applications with better technology and main features meet, the benefit is to create more valuable and richer events by helping attendees to make the best connections possible. Based on these points, in this section we just picked and present the following mobile applications and research projects for meeting, conferences and tradeshows. A discussion of these different mobile applications will be delivered in the following section (Section V) to help determine the paramount features for these applications.

A. UNGERBOECK

It is a mobile application for conferences, meetings, customer relationship management (CRM) and venues developed by USI International. The aim of Ungerboeck (www.ungerboeck.com) is to increase event value and engagement for attendees by providing up-to-date information and a collaborative event experience. Offering attendees with services such as the ability to see a session program, locate other attendees or exhibitors, and learn more about presenters or speakers allows them to make their event participation more interesting. Deploying mobile applications designed to connect organizers and attendees on web-enabled smartphones and mobile devices, including Android, iPhone, Palm, Windows Phone, and Blackberry is quick. It is also compatible with all event management software's that have an easy to use import capability along with the online administrator interface that allows uploading information to the mobile conference application without needing access to Ungerboeck software.

B. GENIECONNECT

GenieConnect (www.geniemobile.com) is a mobile application developed by Genie Mobile Ltd. for transforming event behavior into business intelligence. It is one of the event-based mobile applications to engage attendees, and can be configured accurately to tie needs of the organizers. It also offers an all-inclusive mobile event application appropriate for many kinds of events. Organizers or attendees can add further platforms and modules, such as year-round application configurations or the web portal component as needed. Some of the core functions of GenieConnect: event scheduling, showcase exhibitor profile, speaker profile showcase with bio (including photo) and social media links, sessions link, offer a map of the exhibition floor and venue, using an image, and venue and local info using Google Maps, messages from organizers, access full reporting and analysis of user behavior, exhibitor activity and trends, enable visitors to take text or voice memo and attach them to sessions, exhibitors etc.

C. GRUPIO

Grupio (www.grupio.com) is a mobile application developed by Dharanet LLC. It offers access to event information in an easy-way, facilitates attendees or participants to communicate with each other and also allows organizers/planners to make connection with attendees and many more. It is accessible as a native application (works in an online/offline mode) on the Android, iPhone, and Blackberry (Torch and Storm) and for other handsets as a mobile website. Grupio offers application solutions in various packages (Standard, Custom, and Enterprise) to run into budget and time constraints, as well as the varying functional requirements of event planners.

D. CROWDCOMPASS

CrowdCompass (www.crowdcompass.com) is one of the event-based mobile applications that have all the necessary exclusive features (attendees, sponsors, and exhibitors) to make events more popular. Event participants use the latest advances in social media and mobile trends to turn single event into a fast-growing success by deploying such applications. It is also native to the device they are on, so everyone involved don't need an internet connection for it to function (works in offline mode).

E. QUICKMOBILE

For the growing number of participants, for making attractive revenue, or for building loyalty, QuickMobile applications (MobileEvent, MobileConnect, MobileMembership, MobileAmenities and MobileVenue) are being used to extend events into year-long communication, creating richer involvements, and raising long term relationship among participants. MobileEvent is a flexible, branded and scalable event-based mobile application that substitutes the traditional event guide applications, gives everything needed to initiate participation and build lasting relationships at events. 1) *MobileConnect* is a controllable and flexible application to deploy event guides among the entire society. 2) *MobileMembership* is a new communication channel for an association, by giving the influence to deliver appropriate information and initiate uninterrupted interaction amongst the membership throughout the year - serving to build a loyal, strong membership base with real value. 3) *MobileAmenities* helps to tell venue story with an attractive content and rich media that put the property in the spotlight. 4) *MobileVenue* is a platform that can be used for packing the entire venue sales kit into an interactive iPad application, helping to make user enjoyment.

F. SEEDLABS

SeedLabs (www.seedlabs.com) mobile application is developed at Seed Labs. It helps to push the latest information to attendees' devices; share schedules, photos, bios, audios, maps, videos and other information; and promotes sponsors in a new way. The application also possess attendees with real-time access to event information such as schedules, floor plans, lineups and more, save money on paper brochures (both printing and cleanup), hype up event beforehand to boost ticket sales, distribute announcements during event to smooth logistics, create a community and build buzz around the event with in-app social media sharing, and drive additional value for sponsors and exhibitors with new advertising and messaging platforms. Furthermore, it works both in online and offline modes.

G. PATHABLE

It is a community and social network for conferences. Pathable (www.pathable.com) helps attendees meet, connect, and stay in touch - before, during and after the event. It needed a more flexible and robust design that could be easier to be modified and used for various social events, such as meetings that involve multiple international languages. Pathable new design (Pathable V.2, developed February 2012), designed to be suited for multi-event communities, with discussions classified by event or forums, users easily be able to change language options (add or remove) for worldwide events, due to the new design. As for events with host-organized meetings, an administrative dashboard which is added as a new feature allows editing meeting programs/schedules easier and straightforward; in Version 1, all programs/schedules were uploaded via a traditional ways (i.e. spreadsheets). On the new version, it also able to fully support a workflow for events that involve hosted-buyer professionals, customers are capable of using that application including in an offline mode. Put differently, once they have seen the application on a smartphone with network coverage, the information becomes available all in the browser. Even if they step out of the network range (i.e. WiFi), they will still be able to access the data.

H. ZERISTA

It is developed by Zerista Company (www.zerista.com), introducing event intelligence platform for attendees, organizers and exhibitors. It is a native Andoid, iPhone and iPad apps augmented mobile web applications for all smart devices. It offers an interactive multi-day, multi-track, multi-session conference schedule, session and venue maps, exhibitor listings with interactive expo, interesting attendee relationship/networking, messaging, and participant matching process features, two-way real-time integration with other social networking sites such as Facebook, LinkedIn and Twitter, well-suited and compatible with the Zerista-API for integration with participant registration systems, exhibitor management systems and more than 100 other third party systems.

I. EVENTMOBI

EventMobi (www.eventmobi.com) is an optimized mobile application developed by 5Touch Solutions Inc. Event participants doesn't need to download anything; it identifies what type of phone the participants are using and runs attractively on Android, iPhone, Blackberry, Windows Mobile, Palm, Nokia and any tablet device such as Galaxy and iPad. It ensures attendees accessibility to the mobile conference application irrespective of the type of smart device.

J. FOLLOWME OR CORE-APPS

FollowMe (www.core-apps.com) is a mobile application developed by Core-apps LLC used for attendees, organizers and exhibitors. It would work offline so the person can use it on the airplane or the tradeshow floor where internet service is unreliable.

K. SHERPA-SOLUTIONS

Sherpa (sherpa-solutions.com) developed ActivTouch in 2010 and ActivMetrics in 2012. Starting from way navigation to planning agendas, ActivTouch boasts a host of state-of-the-art and instinctive features and services designed to give true value to the application users. Sherpa is a groundbreaking mobile platform functions seamlessly with a social event, allowing exhibitors and participants/attendees to make the most of their experience. ActivMetrics is an innovative system that has Wi-Fi heat mapping technology to track attendees using their mobile devices and accurately measures and analyses traffic throughout the venue in real time. This functionality gives the user an exceptional insight into attendee behavior.

V. DISCUSSIONS

In the previous section, this paper surveyed some existing mobile applications or research projects for meeting, conferences and tradeshows. There are many types of mobile application platforms for meeting, conferences and tradeshows, each having different solutions and features to overcome some of the challenges pointed out at the above sections. Each of the mobile applications and platforms has their own strengths and weaknesses. No matter how, these applications remain inadequate, with no particular application providing an integrated platform and feature for solving all the draw backs of event-based mobile social applications. Before proceeding further, it is needed to specify the features and benefits [7] this paper will use as a foundation for assessing these mobile applications. To ease the discussion, this paper evaluates these applications based on their main features as depicted in Fig. 3 which comprise solutions for the technical challenges obtained in the review of the previous research works. The resulting list consists of the main features (as shown in Table I) which are the basis for evaluating the different mobile applications and research projects for meeting, conferences, and tradeshows.

According to the fifth edition of Professional Meeting Management (PMM), a *green meeting/sustainable event* is well-defined as incorporating environmental and social concerns in order to minimize the negative impact on the environment throughout all stages of the meeting. Most of the applications corporate green initiatives are ever developing and organic, to provide a shared vision of values using their technology platform to other organizations who also committed to the social corporate responsibility of People Planet and Profit. As shown on Table I, all the mobile applications and research projects support this feature. The features of event-based mobile applications have been taken in to consideration by the mobile applications presented in the previous section.

Most of these applications implemented the features with varying degrees. Only a few applications have addressed assistance for attendees in finding their way and map-

ping around a venue (through exhibit hall, nearby attraction venues, city). For example, Core-Apps, GenieConnect, Seed-Labs and Sherpa-Solution; these applications can even locate attendees' in the exhibit hall and guide them through the hall applying the optimal path between exhibit booths. Although this paper listed and evaluated or commented some mobile applications for the main features of event-based mobile services, QuickMobile 2012 [27] released the so-called *seven pillars* that should be considered for next generation mobile event guide applications as detailed in the remaining part of this section.

A. YEAR ROUND CONVERSATIONS

Event planners can use the mobile event applications to motivate, engage and connect with audiences before, during and after events, making the one-day or weeklong conference or meeting the important point of a year-long conversation. Developing a solution that regularly delivers relevant, updated information and content, builds upon the previous years' experience and creates anticipation for future events is an application that will absolutely remain on the device.

B. CONTENT GENERATION AND INTERACTION

Modern event-based mobile applications can turn events into more dynamic and engaging environments where attendees stop being simply spectators. They become content creators and continuously interact and channel feedback through games, surveys, polls and social media.

C. PROFIT CENTER

Rather than the event guide simply being a cost of doing business, event organizers can approach the development of the application with a focus on using it to drive revenues. The event-based mobile application becomes a profit center rather than a cost center. At the 2011 Mountain Travel Symposium in Beaver Creek, Colorado, event organizers sold a limited number of push notifications on the event-based mobile application to sponsors and community businesses to generate revenue. A local Italian restaurant took the initiative to send out a push notification to users of the event-based mobile application, offering a 20% discount off the entire bill throughout the conference. As a result of the proactive outreach, the restaurant was packed with attendees throughout the conference, leaving other restaurant owners scratching their heads.

D. USER EXPERIENCE

The current event-based mobile application embraces the full graphical capabilities of modern mobile devices. The event-based mobile application is entirely branded to convey the unique visual identity of each hosting organization. Event marketers certainly understand the value of brand marketing and a mobile application speaks volumes to conference attendees about brand positioning as a thought leader, innovator and trusted content provider.

E. PERSONALIZED AND TAILORED EXPERIENCE

The event-based mobile application includes a human-centered design that can be personalized with attendee preferences. The Microsoft TechEd 2011 conference in Beijing, China allowed attendees to create a personalized conference experience using an event-based mobile application. Included was a "Like Minded"element that allowed attendees to access personalization features to specify a number of criteria.

F. SINGLE EVENT MANAGEMENT PLATFORM

Event-based mobile applications are managed and viewed by the event planner using a single web-based platform throughout the entire life cycle of the application, including the development of the application, content creation and management, and real-time analytics and reports. Understanding the interests of current, past and prospective attendees and what they are receptive to during the event and throughout the year leading up to the event will strengthen engagement and cultivate an audience year-round.

G. MULTI-EVENT READY

Event-based mobile applications provide organizations with the ability to deliver multiple events within a single branded mobile application. Business Intelligence software provider QlikView decided to take its 25 city 2011 Business Discovery North America Tour to new heights with a single mobile application for all cities. Conference attendees simply download the QlikView mobile application and select the tour stop of their choice. Once selected, the mobile application automatically populates the road show data for that city, thus providing a seamless event-based mobile experience for all attendees. Event-based mobile applications provide for extreme flexibility and scalability without sacrificing look and feel and the feature rich benefits of a sophisticated event-based mobile application.

There are also major event technology trends that researchers and developers to watch for the coming years. These are: 1) low cost and almost free applications for events and tradeshows; 2) the move or the cross from the early adopters to the majority users of event applications; 3) the proliferation of *Do It Yourself* (DIY) mobile event applications; 4) the standardization of HTML5 for many event mobile applications; 5) faster, cheaper, and more effective conference recording and distribution material; 6) the streamlined connectivity and services for events from *Near Field Communication* (NFC)[1]; 7) the increasing usage of social publishing tools to promote, sponsor, and manage meetings and to involve attendee; 8) the increasing expectation of easy to access and free Wi-Fi by event organizers; and 9) the assistance of ''Indoor Positioning Systems'' in event and tradeshow way-finding and navigation.

[1]NFC is a short-range wireless connection to allow communication between devices when they're touched together.

VI. OPEN ISSUES

Following the discussions, this paper aims at identifying related open issues that were either not addressed by the existing event-based mobile social applications or require further improvements besides the trends to watch for the future, that are listed in the last paragraph of the previous section. Furthermore, possible research directions are outlined.

A. INTEROPERABILITY

Increasing the communication efficiency among users by integrating multiple MSN applications becomes an important issue [6]. However, designing robust event-based mobile applications that allow an efficient integration with other applications is challenging. Boosting standard protocol and interoperability in the social event context would be required to ensure further opportunities for innovation and development. Interoperability is important not only for ensuring the above issues, but also for data distribution, context awareness and privacy in event-based MSN. Furthermore, interoperability between different platforms of event-based MSN (i.e. mobile cloud [83]) would be important.

B. MIDDLEWARE DESIGN

An extensive research and projects have been done to design middleware for Mobile Social Networks in the past few years [84]. Mobile applications (particularly event-based) requires: resource management, mobility transparency support and searching mechanisms, cooperative caching, context-awareness support and high-level cooperative optimization. Some of the design approaches to improve the performance of these event-based mobile social applications are by designing a middleware platform supporting data availability [85], utilizing decentralized architecture, heterogeneity where user devices (such as smartphones, tablets, etc.) with different networks, processing powers, interfaces, battery capacities, operating systems to communicate each other, and multiple languages (for international meetings). Furthermore, the platform should support the situation that can work even when there is no internet or really bad internet (Offline mode).

C. RICH MEDIA

Sharing of multimedia in mobile social events becomes an important issue when attendees and organizers are engaged with the activities of the event [8]. In the future of research, exploring the usage of complex classifier combinations and architectures for rich media sharing needs to be explored. Moreover, by inclusion of more textual resources it's expected to be able to give a richer description of events in video, ultimately bridging the semantic gap for a large set of events. Automatic annotation and image analysis for the purpose of finding the identity of people appearing in a picture at the event place is also another important issue.

D. EVENT DETECTION AND RECOMMENDATION

Event-based social recommendation is basically accomplished based on the known interests of the user and other related ways, without the need for the user to subscribe to an event recommendation service and maintain the subscription to accurately reflect the user's current interests. But, in the future, there will be planning mechanism to engage with various activity and manage all activities rather than specific events. Such mechanism requires use of different information sources and filtering techniques. Contrasting to typical movie/book recommendations, recommending events such as conferences (i.e. the work by Xia *et al.* [86]) is more challenging because of the tendency these social events to have a short existence [4]. In addition, it is believed that as outdoor and indoor localization systems evolve, it will become possible to track users' interests in items such as events directly by detecting their attendance at known social events (conferences or meetings). Even though location-based social networks are constantly emerging, they haven't yet reached a mass of event allowing detection and discovery of fine gained events. Generally, extending the existing approaches to these kinds of social network-based sources of data is an important future research direction.

E. EVENT-BASED MOBILE APPLICATIONS

Event-based mobile services are expected to be common in our daily lives starting from arranging dinner event with friends to an international level meeting or conference with thousands of participants from all over the world and many applications of the event-based mobile systems can be envisioned (e.g., way-finding, housing management, and ticketing or booking). For example, the integration of event-based mobile applications with flight tracking applications can be used to improve the performance of the service both for the attendees and organizers. In addition to that, considering the application specific requirements (e.g., QoS) into account, there is a need for customization of event-based mobile services. There are challenges in developing services and applications for event-based mobile systems at the application layer. Also, to handle large number of participants for an event, it would be essential to consider application scalability.

F. SECURITY AND PRIVACY

Mobile social event information is now being used in ways that may have not been initially envisioned for. For instance, there is an increased number of smart devices capable of running mobile event-based applications which can access personal as well as social group information. This enables applications to be aware of a user's location, profile and preferences. However, existing design models for exchange of these information require users to compromise their privacy and security [87], which are considered to be very important issues. Therefore there is a need for design, development and implementation of solutions for these issues that

lets mobile location-based services to query users' information, without disclosing the identity or compromising it's privacy and security. It is important that such solutions be explored by applying several techniques to block tracibility, provide anonymity, and enable cloaking so that mobile social networks for event services continue to grow exponentially.

G. OTHER CHALLENGES

In addition to the above described open issues for the research, there are also some issues that need to be explored by the academics and industry research community. To mention some of them: application of crowdsourcing [88] and crowd sharing for events; discontinued use of mobile social networking applications (specifically for event-based social services); the challenge of application and service development for event-based MSNs. For example: integration with public safety, vehicular communication, and emergency network; architecture and protocol design in approaches like, community tracking and detection, content distribution, network metrics usage and estimation, cross-layer design and resource efficiency. Furthermore, influence of social-behaviors-based relation on the radio resource management of different event-based mobile application wireless systems must be considered in order to truly realize the full positive potential of event-based mobile applications.

VII. CONCLUSION

Event-based MSN is an emerging paradigm which would transform the way people interact and exchange data. In this paper, we have presented a broad review of the existing work on event-based MSN services, technologies and applications. It presented an overview of event-based MSN with their working principles and architecture, explored mobile event-based social networks and smartphone contained technology elements, highlighted and discussed the features of existing mobile applications for social events. Furthermore it also discussed benefits and trends to watch for mobile event-based applications. Hence, this paper recognized numerous open issues and challenges that need to be entirely addressed and solved before developing an all-inclusive application for social event that can run on smartphones. Several event tailored application platforms have different design features and tasks. However, these event-based mobile applications remain unsatisfactory for users, as there is no single application that provides an integrated feature to address all the issues of application for event-based social services. Finally this work states that there is still a lot that has to be completed on the design features before developing an all-inclusive event-based social application for smartphones. The favorable advantages of event-based MSNs are more than likely to be recognized when all the concerned bodies such as researchers, designers and developers start working together.

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