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Urban Microclimate and Traffic Monitoring with Mobile Wireless Sensor Networks

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1. Introduction

Climate is usually defined as the *average* of the atmospheric conditions over both an extended period of time and a large region. Small scale patterns of climate resulting from the combined influence of topography, urban buildings structure, watercourses, vegetation, are known as *microclimates*, which refers to a *specific* site or location. The microclimate scale may be at the level of a settlement (urban or rural), neighborhood, cluster, street or buffer space in between buildings or within the building itself. Specifically, the dispersion and dilution of air pollutants emitted by vehicles is one of the most investigated topics within urban meteorology, for its fundamental impact on the environment affecting cities of all sizes. This issues concern the average and peak values of various air pollutants as well as their temporal trends and spatial variability. The accurate detection of these values might be advantageously exploited by public authorities to better plan the public and private transportation by evaluating the impact on people health, while controlling the greenhouse phenomenon.

As the unpredictable nature of a climate variations requires an incessant and ubiquitous sensing, Wireless Sensor Networks (WSNs) represent a key technology for environmental monitoring, hazard detection and, consequently, for decision making (Martinez et al., 2004). A WSN is designed to be self-configuring and independent from any pre-existing infrastructure, being composed of a large number of elementary Sensor Nodes (SNs) that can be large-scale deployed with small installation and maintenance costs.

Literature contains several examples of frameworks for evaluating the urban air quality with WSNs, as it is reported in (Santini et al., 2008). In addition, in (Cordova-Lopez et al., 2007) it is addressed the monitoring of exhaust and environmental pollution through the use of WSN and GIS technology. As micro-climate monitoring usually requires deploying a large number of measurement tools, in (Shu-Chiung et al., 2009) it is adopted vehicular wireless sensor networks (VWSNs) approach to reduce system complexity, while achieving fine-grained monitoring.

Another aspect strictly correlated with microclimate establishment is represented by the ecologic footprint of traffic congestion due to inefficient traffic management. As a consequence, an increasing number of cities are going to develop intelligent transport system (ITS) as an approach to harmonize roads and vehicles in optimized and green paths. ITSs involves several technologies as advanced informatics, data communications and transmissions, electronics and computer control with the aim of real-time traffic reporting and alerting. Such a framework allows remote operation management and self-configuration of traffic flows, as well as specific information delivering to vehicles concerning, for instance, traffic congestion or the presence of accidents (Pinart et al., 2009)[1]. Thus, the research on data acquisition scheme has become a key point to enable effective ITSs.

At present, the acquisition of real-time traffic data is by means of installation and use of *wired* monitoring equipment in most cities. However several concerns are associated with this choice: firstly, with the continuous expansion of the city size and the increasing or the traffic roads, the more the number of wired monitoring equipment increases, the more the cost grows (*scalability*). Further, the installation of wired monitoring equipment does not have the flexibility, being difficult to (re)deploy. Finally, as urban traffic congestion has a certain degree of space-time randomness, then it is inappropriate to install monitoring equipment in *fixed* locations. On the other hand, large-scale universal installation will cause larger waste. To solve these problems, a promising approach is currently represented by WSNs applicable to all types of urban environment (Laisheng et al., 2009), as they have no space constraints, flexible distribution, mobile convenience and quick reaction.

2. Background

2.1 ITS Communications Paradigms Overview

ITS services availability relies on the presence of an infrastructure usually comprising fixed devices interconnected by an underlying network, either wired or wireless. Data exchange toward or among mobile terminals is inherently wireless, since information should directly reach the drivers through PDAs or on-board transceivers; in evidence, IEEE 802 committee has activated 11p Task Group to define a Wi-Fi extension for Wireless Access in Vehicular Environments (WAVE) (Jiang & Delgrossi, 2008). Moreover, wireless connections are needed also for data gathering, according to the Wireless Sensor Network (WSN) paradigm, comprising large number of devices in charge of sensing and relay informations to the core network (Tubaishat et al., 2009).

Within the above scenario, several communications paradigms are possible (Yousefi et al., 2006). The case in which fixed Access Points (APs) allow mobile nodes to join the network is usually referred as *infrastructure-to-vehicle* (I2V) communications and can support advanced applications such as web surfing, multimedia streaming, remote vehicle diagnostics, real time navigation, to name a few; on the other side, *vehicle-to-vehicle* (V2V) communications represent the option in which mobile nodes can directly communicate to each other without any need of infrastructure. Although V2V and I2V communications are both prominent research fields, this paper is mainly focused on the latter, as it aims to efficiently exchange short amounts of data, collected and aggregated by an in-field deployed WSN, to nomadic users, while keeping the complexity of on-board circuitry as low as possible. It is worth noticing that a reliable I2V scheme is extremely valuable even for V2V communications since, whenever a direct link among vehicles is not available, message exchange can leverage on the infrastructure instead of being successively relayed by few low-reliable mobile nodes, as addressed in (Gerla et al., 2006).

The urban environment is usually composed of a large number of mobile terminals that are likely to quickly change their reference AP, therefore facing frequent disconnection and re-connection procedures, so that it may be not viable to deliver the total amount of required data within a single session. Moreover, the urban channel is affected by long and short term fading that introduces additional delays for data retransmissions (in the case of TCP traffic)

[1] These goals could be summarized in two main fields as traffic flow *forecast* and traffic *congestion control*.

or sensibly lowers the data reliability (in the case of UDP traffic); these issues are addressed in details in (Bychkovsky et al., 2006) and (Ott & Kutscher, 2004), providing a practical case study involving IEEE 802.11b.
In general, content distribution through overlay networks is more efficient when compared to traditional solutions using multiple unicasts. In order to achieve higher throughput and failure resilience, parallel downloading from multiple overlay nodes represents a typical approach in most recent proposals (Wu & Li, 2007). However, the same content may be unnecessarily supplied by multiple nodes, rising the problem of the so called content reconciliation, which usually is a time and bandwidth consuming operation (Byers, Considine, Mitzenmacher & Rost, 2002).

2.2 Rateless Codes

Rateless (or digital fountain) codes are a recently introduced class of forward error correction codes with universally capacity-approaching behavior over erasure channels with arbitrary erasure statistics. The first practical rateless codes, called LT codes (Luby, 2002), are based on a simple encoding process where the source message of length k information symbols is encoded into a message containing a potentially infinite number of encoded symbols. Each encoded symbol is an independently and randomly created representation of the source message and, as soon as the receiver correctly receives any set of k' encoded symbols, where k' is only slightly larger than k, it is able to recover the source message.
LT encoding process is defined by the LT code degree distribution $\Omega(d)$, which is a probability mass function defined over the interval $[1, k]$. To create a new encoded symbol, the degree d is randomly sampled from the degree distribution $\Omega(d)$, d information symbols are uniformly and randomly selected from the information message, and the encoded symbol is obtained by XOR-ing d selected information symbols. Usually, information and encoded symbols are equal-length binary data packets and the XOR operation is the bit-wise XOR. Encoded symbols are transmitted over an erasure channel and decoded at the receiver using the iterative Belief-Propagation (BP) algorithm. BP algorithm for erasure channel-decoding iteratively recovers information symbols from the degree one encoded packets, and cancels out the recovered information symbols in all the remaining encoded packets (which may result in a new set of degree one encoded packets). The iterations of this simple process can lead to the complete message recovery, otherwise the receiver will have to wait for additional encoded packets in order to complete the decoding process. The key problem of LT code design is the design of the degree distribution $\Omega(d)$ that will enable source message recovery from any slightly more than k received encoded symbols using the iterative BP decoding algorithm. This problem is solved asymptotically in (Luby, 2002), where it is shown that using so called robust soliton degree distribution, it is possible to recover the source message from any k' encoded symbols, where $k' \to k$ asymptotically, with encoding/decoding complexity of the order $O(k \cdot logk)$.
Rateless codes are usually applied in multicast scenarios, where the source message is entirely available to the source node. However, in many practical systems such as wireless ad-hoc networks, WSN or p2p networks, the message of interest might be distributed over many or all network nodes. As shown recently - see (Vukobratovic et al., 2010) and references therein - distributed rateless coding may be performed as efficiently as its centralized counterparts, and may provide a number of benefits in distributed network scenarios for applications such as data gathering, data persistence and distributed data storage.

3. Proposed Approach

3.1 System Requirements and Architecture

The reference system model is derived from a real world case study, inspired by the Tuscany Region project "Metropolitan Mobility Agency Supporting Tools" (SSAMM), devoted to enhance the quality of urban transportation system introducing innovative paradigms. The addressed urban communications scenario is modeled as a two-level network, as illustrated in Fig. 1. In particular, the lower level is composed of a large number of Sensor Nodes (SNs), positioned in such way that suitable and effective sampling of the road traffic is achieved within the area of interest (Tanner, 1957). Whenever possible, SNs are deployed in correspondence with road infrastructures such as posts, lamps and traffic lights, typically arranged in a square grid fashion. Their purpose is to collect traffic flow information[2] and relay it to the higher layer consisting of interconnected network of APs. In addition to this fixed SNs, also mobile sensors are introduced; it could be the case of a public vehicle equipped with gas analyzers for the classical air pollutants NO, NO_2, O_3 and NO, in order to record air pollution and meteorological data within different urban zones. In the meanwhile vehicles can deliver information regarding the interarrival time between adjacent APs, which is useful in estimating the congestion level. Finally, APs deliver gathered data toward Mobile Collector (MC) usually referred to as *data mule*.

As the proposed application scenario is concerned with fast and efficient information retrieval, these drawbacks could be faced by introducing an appropriate *data dissemination* algorithm, enhancing the information *persistence* throughout the network without an excessive overload in terms of total packet transmissions. To face MC inherent mobility, a *distributed data gathering* protocol has been introduced (Stefanovic et al., 2011) to efficiently collect all the sensed data by visiting only an arbitrary subset of the SNs; this general requirement is extremely important in urban scenarios, since path are usually space-time *constrained*. This has been achieved resorting to a distributed implementation of rateless codes (Byers, Luby & Mitzenmacher, 2002), a particular class of erasure correction codes that rely on sparse binary coefficient data combining, being suitable for the envised I2V data dissemination application, in which devices exhibit low computational capabilities. Moreover, it has been introduced an adequate *data dissemination protocol* which has been integrated with a MC *data gathering* scheme specifically designed for a urban wide area monitoring WSN in order to allow reliable and accurate sensing collection.

3.2 Communications Scheme

Each homogeneous subset of SNs is connected in a star-wise or tree topology to an AP; APs encode and exchange packets received from SNs, then broadcast the information to MCs. MCs usually join the network without need of an association with a specific AP by adopting a *passive operation mode* and continuously collecting information regarding the surrounding environment broadcasted by APs[3]. Nevertheless, whenever MCs are involved in disseminating their own information, they explicitly associate to the best AP and operate both in *transmitting* and *receiving* modes. However, inter-vehicle communications are not hereafter considered. Finally, we assume that MCs have on-board capabilities to process the downloaded data according to suitable applications in order to interpret current traffic information. Specifically,

[2] Different types of information, e.g., average crossroad waiting time, presence of roadworks or accidents, could be of interest.

[3] This is adopted in order to lower the implementation complexity and cost of the mobile equipment, minimize the downloading time avoiding access contentions and complex handover procedure.

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the collected real-time data provide opportunity for on-board computer to perform optimal route calculation, delay estimates, and present driver with visual map representation of critical locations where accidents, high pollutants concentrations or severe road congestions took place. Although the push mode is possible, data processing is usually implemented in an automatic (i.e., periodic) manner in order to guarantee as much as possible real-time monitoring of the traffic-load conditions. In particular, the latter mode of operation makes it possible for MCs to be informed about dangerous situations (e.g., accidents) in a short time span, hence allowing for increased safety of people and vehicles.

The communication between SNs (even mounted on board of a MC) and APs, and between MCs and APs, is assumed to be based on wireless technology. As recently shown, IEEE 802.11b/g standards demonstrated significant potential for vehicular applications (Bychkovsky et al., 2006). Another candidate could be IEEE 802.11p (still in the draft stage), whose one of the aims is to support efficient data exchange between roadside infrastructure and vehicles.

Regarding the communications between APs, it is accomplished by leveraging on a pre-existing infrastructure deployed in a urban area, i.e., connecting APs to wired Metropolitan Area Network (MAN), such the one adopted by Florence Municipality, called *FI-Net*, comprised of a double fiber optics ring with a 2×2.5 Gbps full-duplex capacity. Full-mesh wireless interconnections are not considered as the adoption of an IEEE 802.11 unique radio interface could pose several limitations in terms of coverage or, equivalently, scalability.

However, the communication scenario described above fits in the infrastructure mode of the IEEE 802.11 standard in which several APs are interconnected using an external distributed system, forming an *Extended Service Set* (ESS).

3.3 Distributed Data Gathering, Encoding and Dissemination

The system application, residing in APs, periodically performs the following three procedures, according to (Stefanovic et al., 2011): (i) data gathering from SNs, (ii) encoding and (iii) disseminating encoded data to MCs. We refer to these three stages as upload, encoding and download phase, respectively, and the period encompassing all of them as *data refreshment period*. According to the IEEE 802.11 standard, the link time in every AP coverage zone is divided in superframes (IEEE, 2007), and the data refreshment period in each zone is aligned with superframe boundaries (see Fig. 2).

During the upload phase, every AP polls all SNs in its domain[4] and collects the most recent measurements. As typically foreseen by most of the IEEE 802.11 standards (IEEE, 2007), superframes are divided into the Contention-Free Period (CFP) and Contention-Based Period (CBP), where the former is used to avoid MAC collisions and deliver prioritized information to MCs. The polling phase can be accomplished within the CFP part of a typical frame. CFP always starts after a beacon with a delivery traffic information map (DTIM) field sent by AP to STAs (that is SNs in our case). STAs associated with AP learn when the CFP should begin and automatically set their NAV to MaxCFPDuration when the CFP is expected to begin. Then AP individually polls each STA with a CF-poll message waiting for DATA and CF-ACK messages from it, where messages are separated by a Short Interframe Space (SIFS) period. We assume

[4] SNs can be either fixed, i.e., infrastructured, or mobile, i.e. on board of MCs. In the latter case it is necessary that the sojourn time of MC is comparable with superframe. This condition is easily satisfied in the case of public transportation means close to a regular or temporary stop where an AP has been placed.

Fig. 1. Reference network topology for general I2V applications.

that APs are globally synchronized[5], so the actual upload takes place in the *first* superframe period following the start of the data refreshment period. Each SN uploads its measurements within a single data packet of length L bits. Since SNs and APs form an *infrastructured* network, it has been supposed that nodes have been previously deployed in line-of-sight (LoS) fashion in order to optimize link quality; however possible packet losses are managed by means Automatic Repeat reQuest (ARQ) scheme, so that from an application point of view data delivering could be considered reliable. In particular, to match the constraint of polling completion within the first frame, a maximum ARQ retransmission persistency equal to N_A attempts, where this parameter is selected in order to yield a negligible *residual* packet error probability.

On reception, AP stores and uniquely indexes each received data packet, where the indexing scheme is known to all APs. The total number of stored data packets in APs network per data refreshment period is k, which is equal to the total number of SNs. These k data packets represent a single data generation, upon which the rateless coding is performed. The differentiation among data generations can be achieved using appropriate field in packet header, allowing MCs to maintain global time-references.

After the upload phase, the system application, distributed over all APs in the network, performs distributed rateless encoding of collected data packets (i.e., rateless coding is used at the

[5] It is easily provided by the preexisting MAN communications infrastructure which arrange a sort of *APs network*.

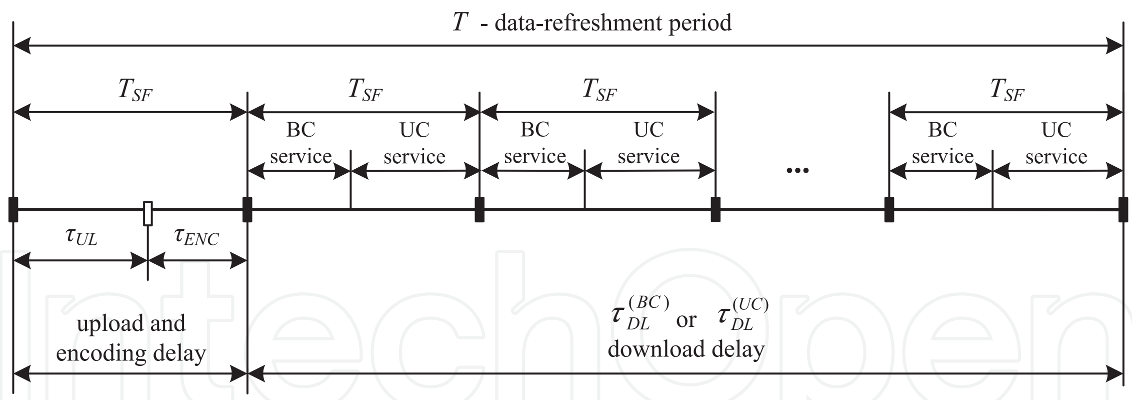

Fig. 2. Data refreshment period of the proposed application.

application level). Each AP independently produces k_{AP} encoded packets, where the actual value of k_{AP} is chosen such that it is sufficient for successful data recovery by all MCs with high probability (w.h.p.). Specifically,

$$k_{AP} \geq \left(\frac{1 + \epsilon^{(\max)}}{1 - P_{PL}} \right) \cdot k$$

where $\epsilon^{(\max)}$ is the reception overhead that allows for decoding w.h.p. and which depends on the properties of the applied rateless codes, while P_{PL} is the estimated link-layer packet loss probability. For each encoded packet, AP draws degree d from the employed degree distribution and then randomly selects d data packets from the pool of all k data packets residing in the AP network during the *current* data refreshment period. In general case, most of the selected data packets are likely to be stored in other APs, so the AP has to request them using the known indexing scheme. After reception of the missing data packets, AP creates encoded packets by simple bitwise XOR of associated data packets.

Finally, in the download phase, each AP disseminates encoded packets by simply *broadcasting* them to MCs currently falling in its coverage area. This approach has been adopted in order to minimize the complexity and the power consumption of MC receiver by always keeping it in a receiving mode. Depending on the provided service, two kinds of dissemination are possible: broadcast (BC) and geocast (GC) ones. The BC service covers simultaneous *global* distribution of the most important data such as key traffic info to all the associated MCs, using the broadcast MAC address. The GC service could be used for an additional (e.g., traffic congestion and air quality) *local* delivering of uncoded packets containing information on the actual hot spot (e.g., context aware information for navigation software enahnced services).

Due to its duration and broadcast nature, the BC service is capable of delivering significantly larger amount of data per superframe to its users as compared to the GC service, which is why the former is preferable for delay-sensitive real-time information delivery. The dissemination starts in the first superframe that follows the encoding phase, and lasts until the next data collection phase (i.e., the next data refreshment period). For the purpose of BC service, the natural choice is to use CFP part of the superframe, as it guarantees delivery of traffic-info updates to all subscribed MCs within the service area.

While traveling within the service area, each MC performs a channel sensing at periodic intervals (say θ), dynamically selects the best carrier and transparently roams among adjacent APs, while downloading encoded packets from APs, until it collects enough for sensor data recovery using the iterative BP algorithm. The number of excessive encoded packets compared to k sensor packets is measured by the reception overhead ϵ[6]; i.e., for successful recovery MC needs in total $k' = (1 + \epsilon') \cdot k$ encoded packets, where ϵ' usually is a small positive number. Since each encoded packet is an innovative representation of the original data, *any* subset of $k' = (1 + \epsilon') \cdot k$ taken from the set of *all* the encoded packets in the network allows for restoration of the whole original data. This property of rateless codes makes them a perfect candidate to be used at the application level for content delivery in vehicular networks, since packet losses caused by the varying link characteristics are compensated simply by reception of the new packets and there is no need for standard acknowledgment-retransmission mechanisms which can not be supported by a semi-duplex architecture as the one adopted. In other words, the usage of connection-oriented transport protocols like TCP can be avoided, as UDP-like transport provides a satisfactory functionality. Moreover, the loosing of packets caused by channel error or by the receiver deafness during the selection of a different AP does not impact on BC scheme, as MC continues downloading data *without* any need for (de/re)association, session management or content reconciliation.

4. Simulation Results

The simulation setup assumes that the urban area is covered by a regular hexagonal lattice, where each non-overlapping hexagon represents the coverage area of a single AP and the hexagon side length is equal to the AP transmission range. MCs move throughout the lattice using the rectangular grid that models urban road-infrastructure, associating with the nearest AP. The overlay hexagonal AP lattice is independent and arbitrarily aligned with the underlying rectangular road-grid. The MCs move according to the Manhattan mobility model (Bai et al., 2003), a model commonly used for metropolitan traffic. In brief, Manhattan mobility model assumes a regular grid consisting of horizontal and vertical (bidirectional) streets; at each intersection, MC continues in the same direction with probability 0.5 or turns left/right with probability 0.25 in each case. The MC speed is uniformly chosen from a predefined interval and changes on a time-slot basis (time-slot duration is a model parameter), with the speed in the current time-slot being dependent on the value in the previous time-slot. Besides temporal dependencies, Manhattan mobility model also includes spatial dependencies, since the velocity of a MC depends on the velocity of other MCs moving in the same road segment and in the same direction; as we are interested only in I2V communications from the perspective of a single user (i.e., a single MC), spatial dependencies are omitted in our implementation.

The purpose of the simulations is to estimate the duration of the download phase, as the most important and the lengthiest phase of the data refreshment period. In each simulation run, while moving on the road grid, the MC starts receiving the encoded data from the AP in whose coverage zone it is currently located. The reception of the encoded packets continues until the MC collects enough to successfully decode all the original data. If during this process, MC happens to move to another AP zone, it simply associates to a new local AP (i.e., handover takes place) and starts to receive its encoded packets. Also, if the AP has transmitted all of its encoded packets to the MC, but it failed to decode the data (e.g., due to link-layer packet losses), the MC suspends data reception until it enters the new AP coverage zone. The

[6] This takes into account both the decoding overhead as well as the redundancy needed in the presence of erasure channel.

simulation run ends when the decoding is finished and all the original data packets are retrieved. All the presented results are obtained by performing 1000 simulation runs for each set of parameters.

System Parameter	**Value**
AP transmission range	400 m
N_{AP} (no. of APs in the system)	40
N_s (no. of sensor nodes per AP)	50
k (no. of data packets)	2000
L (data packet length)	250 byte
$k \cdot L$ (total amount of original data)	4 Mbit $\approx$ 0.48 Mbyte
c, δ (rateless code parameters)	0.03, 0.5
k_{AP} (no. of encoded packets per AP)	3600
R (bit-rate)	6, 11, 12, 24 Mbit/s
T_{SF} (superframe duration)	100 ms
τ_{HO} (handover time)	0.5 s
P_{PL} (packet-loss probability)	0.3
road-segment length	150 m
velocity	4 - 17 m/s
acceleration	$\pm$ 0.6 m/s^2
mobility model time-slot duration	2 s

Table 1. Simulation Parameters

Table 1 summarizes the values for the communication and mobility model parameters used in simulations. The number of APs is chosen such that it provides a coverage area which is approximately equal to a medium-sized city area. The data packet length is estimated in such way that is sufficient to accommodate single sensor readings and additional headers (i.e., IEEE 802.11 MAC and LLC, network and transport layer). The values for bit-rate and superframe duration are selected as suggested in (Bohm & Jonsson, 2008) and (Eriksson et al., 2008), pessimistic assumption on packet-loss rate and estimate of the mean MC handover time were taken from (Bychkovsky et al., 2006), the average road segment length (i.e., average distance between two intersections) from (Peponis et al., 2007). The number of encoded packets per AP, k_{AP} is chosen such that a MC could decode all original data with probability of 0.99, when downloading from a single AP and considering employed rateless code properties and assumed link-layer packet-loss rate. In other words, $k_{AP} > \left(1 + \epsilon^{(max)}\right) \cdot k \cdot L/(1 - P_{PL})$.

Fig. 3 presents the probability P_{SD} that the MC successfully decodes the sensor data as a function of time, for the BC service and $T_{SF}^{(BC)} = 0.1 \cdot T_{SF}$. The value for T_{SF} is selected such that it leaves enough room for the GC service and other usual best-effort services. As it can be observed from the figure, for higher bit-rates (i.e., $R > 6$ Mbit/s), the MCN is able to successfully decode w.h.p. all the data in the time span of several seconds. The positive effect of rateless coding is inherent in the fact that, even in the worst case, the data refreshment period is below 15s, a value that still allows for real-time information updates and which could be decreased further by assigning a larger superframe fraction to the BC service. As opposed to rateless encoded data delivery, the uncoded data delivery would result in retransmission feedback implosion for BC service, overwhelming the sender (i.e., AP) with unwanted traffic. The probability of successful decoding for GC service is presented in Fig. 4, where the fraction of the superframe assigned to a single user is assumed to be $T_{SF}^{(GC)}/N_{MN} = 0.01 \cdot T_{SF}$; the values for $T_{SF}^{(UC)}$ and N_{MN} are taken from the realistic analysis given in (Bohm & Jonsson, 2008). Fig. 4 demonstrates that for the standard GC service, the data refreshment period is of the order of minutes rather than seconds, which limits its usage for the applications that tolerate larger update periods. However, this period would be significantly longer if rateless coding was not used, since the link layer retransmissions would make the data delivery process considerably less efficient. Finally, it can be observed that, for the GC service, the differences in transmission bit-rate have a significant impact on the download delay, which makes higher bit-rates desirable.

Fig. 5 presents the duration of the time interval $T_{0.99}$ for which a MN, using the GC service, decodes all the original data with probability $P_{SD} = 0.99$, as a function of the number of users N_{MN} and for the fixed $T_{SF}^{(GC)} = 0.8 \cdot T_{SF}$. The figure shows a linear increase in $T_{0.99}$ as the rate decreases or N_{MN} increases, verifying that the content reconciliation phase is indeed unnecessary, since the change of the AP does not introduce additional delays apart from the handover time. In other words, after a handover, MC seamlessly advances both with the receiving and decoding processes.

Finally, Fig. 6 shows the cumulative distribution function F_T of the number of transmitted packets using the GC service from an AP to any MC within a single AP domain. The $T_{SF}^{(GC)}/N_{MN}$ ratio of the UC service is set to $0.005 \cdot T_{SF}$ or $0.01 \cdot T_{SF}$. As it can be observed, the number of transmitted packets to a MC reaches the threshold value k_{AP} equal to 3600 for the selected parameter values (Table I), in all cases but for $R = 6$ Mbit/s and $T_{SF}^{(GC)}/N_{MN} = 0.005 \cdot T_{SF}$. This means that number of encoded packets per AP (i.e., k_{AP}) is properly dimensioned to allow a single user to collect enough of encoded packets to decode all the data w.h.p. while moving through a single AP coverage zone.

To summarize the benefits provided by the proposed I2V data dissemination based on the rateless codes over traditional methods, it is worth noticing first of all that, by their design, rateless codes are tuned to the changing wireless link conditions and have a close-to-the-minimal reception overhead. Furthermore, each rateless coded packet is an equally important representation of the original data, which makes lengthy TCP-like reliability mechanisms unnecessary. These factors influence the time allocations within the superframe, allowing larger number of mobile nodes to be serviced during designated service-time portion of the superframe, or alternatively, service-time portion shortening, providing larger time allocations for best-effort traffic. Finally, while roaming through the network, mobile users can simply continue with data download from the new local AP after a handover, avoiding the redundant content reconciliation phase.

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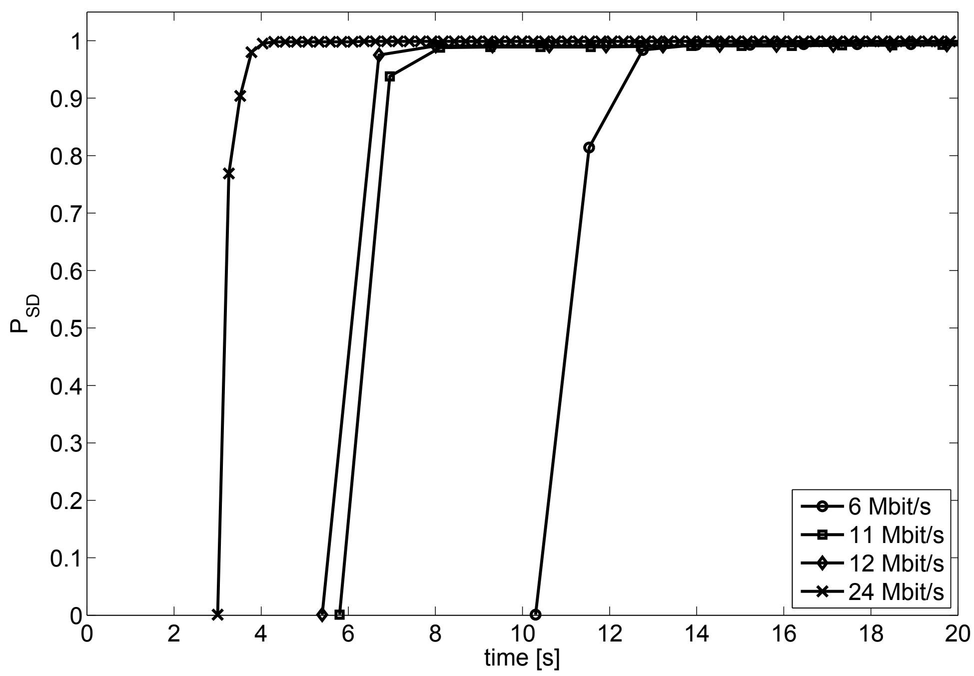

Fig. 3. Probability of successful decoding P_{SD} for BC service, $T_{SF}^{(BC)} = 0.1 \cdot T_{SF}$.

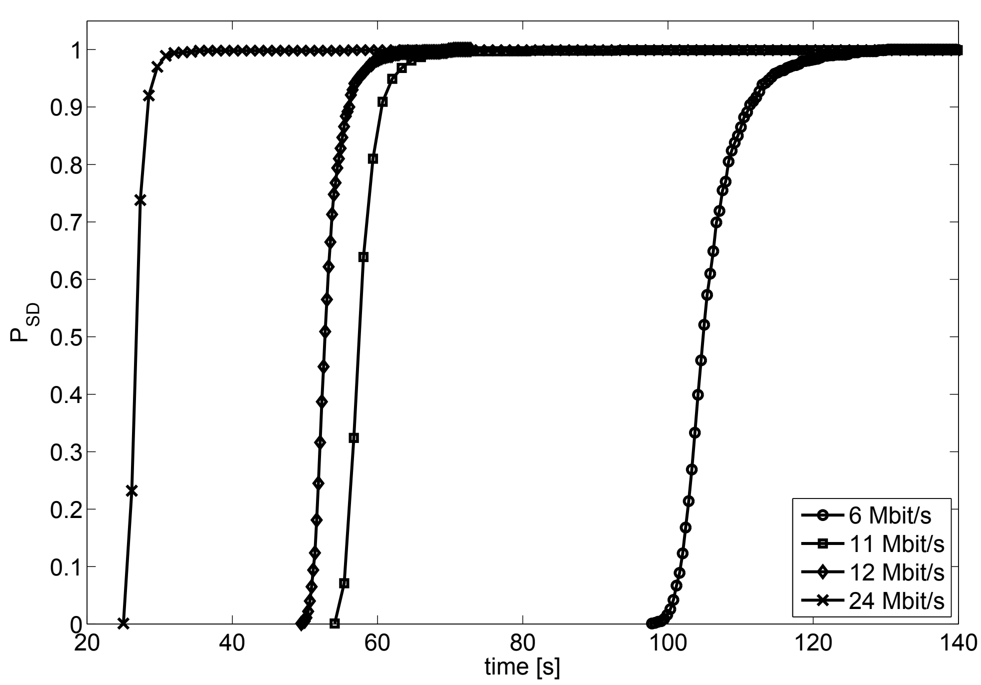

Fig. 4. Probability of successful decoding P_{SD} for GC service, $T_{SF}^{(GC)} / N_{MN} = 0.01 \cdot T_{SF}$.

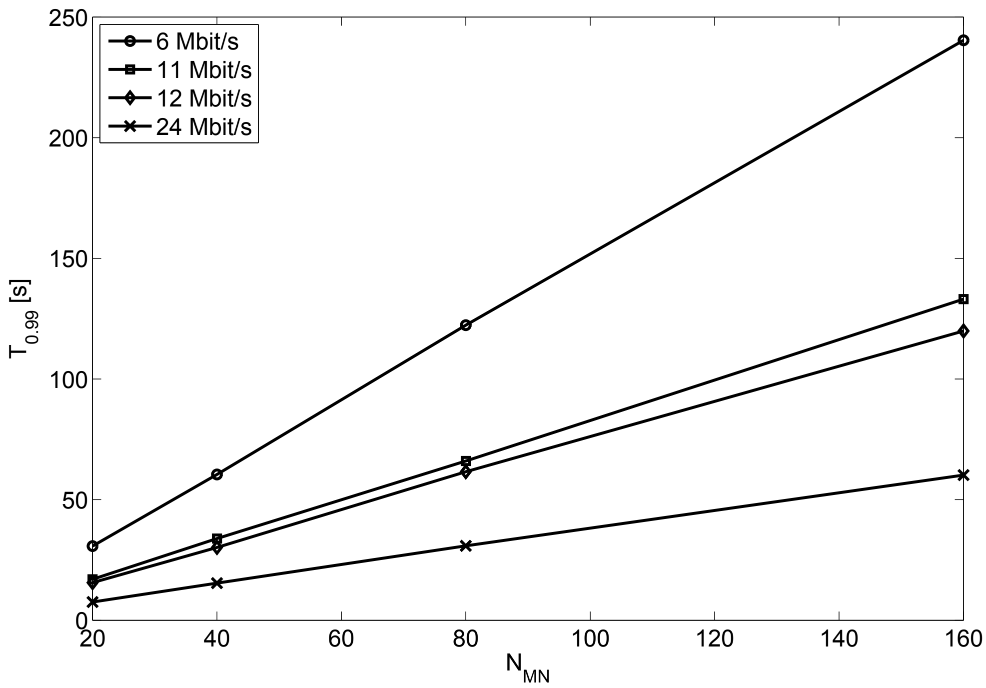

Fig. 5. Duration of time-interval $T_{0.99}$ for which MC decodes all data with $P_{SD} = 0.99$ for GC service.

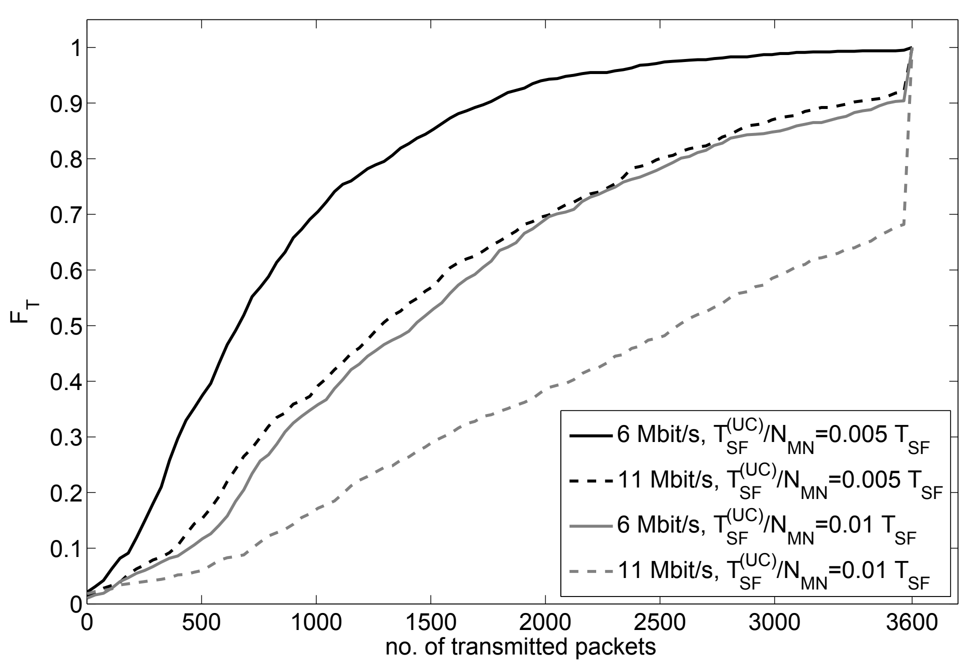

Fig. 6. Cumulative distribution function F_T of number of transmitted packets to MN in single AP cell for GC service.

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5. References

Bai, F., Sadagopan, N. & Helmy, A. (2003). IMPORTANT: A framework to systematically analyze the Impact of Mobility on Performance of RouTing protocols for Adhoc NeTworks, *Proc. of IEEE INFOCOM 2003*, San Francisco, CA, USA.

Bohm, A. & Jonsson, M. (2008). Supporting real-time data traffic in safety-critical vehicle-to-infrastructure communication, *Proc. of IEEE LCN 2008*, Montreal, QC, Canada.

Bychkovsky, V., Hull, B., Miu, A., Balakrishnan, H. & Madden, S. (2006). A Measurement Study of Vehicular Internet Access Using *in Situ* Wi-Fi Networks, *Proc. of ACM MobiCom 2006*, Los Angeles, CA, USA.

Byers, J., Considine, J., Mitzenmacher, M. & Rost, S. (2002). Informed Content Delivery Across Adaptive Overlay Networks, *Proc. of ACM SIGCOMM 2002*, Pittsburg, PA, USA.

Byers, J., Luby, M. & Mitzenmacher, M. (2002). A Digital Fountain Approach to Asynchronous Reliable Multicast, *IEEE Journal on Selected Areas in Communications* **20**(8): 1528–1540.

Cordova-Lopez, L. E., Mason, A., Cullen, J. D., Shaw, A. & Al-ShammaŠa, A. (2007). Online Vehicle and Atmospheric Pollution Monitoring using GIS and Wireless Sensor Networks, *Proc. of ACM IntŠl Conference on Embedded Networked Sensor Systems (SenSys)*, pp. 87Ű–101.

Eriksson, J., Balakrishnan, H. & Madden, S. (2008). Cabernet: Vehicular Content Delivery Using WiFi, *Proc. of ACM MobiCom 2008*, San Francisco, CA, USA.

Gerla, M., Zhou, B., Lee, Y. Z., Soldo, F., Lee, U. & Marfia, G. (2006). Vehicular Grid Communications: The Role of the Internet Infrastructure, *Proc. of WICON Š06*, Boston, MA, USA.

IEEE (2007). Ieee 802.11-2007 wireless lan medium access control and physical layers specifications.

Jiang, D. & Delgrossi, L. (2008). IEEE 802.11p: Towards an International Standard for Wireless Access in Vehicular Environments, *Proc. of IEEE VTC2008-Spring*, Singapore.

Laisheng, X., Xiaohong, P., Zhengxia, W., Bing, X. & Pengzhi, H. (2009). Research on traffic monitoring network and its traffic flow forecast and congestion control model based on wireless sensor networks, *Measuring Technology and Mechatronics Automation, 2009. ICMTMA '09. International Conference on*, Vol. 1, pp. 142 –147.

Luby, M. (2002). LT Codes, *Proc. of IEEE FOCS 2002*, Vancouver, BC, Canada.

Martinez, K., Hart, J. & Ong, R. (2004). Environmental Sensor Networks, *IEEE Computer Journal* **37**: 50–56.

Ott, J. & Kutscher, D. (2004). Drive-thru Internet: IEEE 802.11b for Automobile Users, *Proc. of IEEE Infocom 2004*, Hong Kong.

Peponis, J., Allen, D., Haynie, D., Scoppa, M. & Zhang, Z. (2007). MEASURING THE CONFIGURATION OF STREET NETWORKS: the Spatial profiles of 118 urban areas in the 12 most populated metropilitan regions in the US, *Proc. of 6th International Space Syntax Symposium*, Istanbul, Turkey.

Pinart, C., Calvo, J. C., Nicholson, L. & Villaverde, J. A. (2009). ECall-compliant early crash notification service for portable and nomadic devices, *Proc. of IEEE VTC2009-Spring*, Barcelona, Spain.

Santini, S., Ostermaier, B. & Vitaletti, A. (2008). First Experiences using Wireless Sensor Network for Noise Pollution Monitoring, *Proc. of 3rd ACM Workshop on Real-World Wireless Sensor Networks (REALWSN'08)*, Glasgow, United Kingdom.

Shu-Chiung, H., You-Chiun, W., Chiuan-Yu, H. & Yu-Chee, T. (2009). A Vehicular Wireless Sensor Network for CO2 Monitoring, *Proc. of IEEE Sensors*, pp. 1498 – 1501.

Stefanovic, C., Crnojevic, V., Vukobratovic, D., Niccolai, L., Chiti, F. & Fantacci, R. (2011). Urban Infrastructure-to-Vehicle Traffic Data Dissemination Using Rateless Codes, *to appear in IEEE Journal on Selected Areas on Communications special issue on Vehicular Communications and Networks* .

Tanner, J. C. (1957). The Sampling of Road Traffic, *Journal of the Royal Statistical Society. Series C (Applied Statistics)* **6**(3): 161–170.

Tubaishat, M., Zhuang, P., Qi, Q. & Shang, Y. (2009). Wireless sensor networks in intelligent transportation systems, *Wireless Communications and Mobile Computing 2009* **9**(3): 287–302.

Vukobratovic, D., Stefanovic, C., Crnojevic, V., Chiti, F. & Fantacci, R. (2010). Rateless Packet Approach for Data Gathering in Wireless Sensor Networks, *to appear in IEEE Journal on Selected Areas in Communications special issue on Simple Wireless Sensor Networking Solutions)* **28**(7).

Wu, C. & Li, B. (2007). Outburst: Efficient Overlay Content Distribution with Rateless Codes, *Proc. of IFIP Networking 2007*, Atlanta, GA, USA.

Yousefi, S., Mousavi, M. S. & Fathy, M. (2006). Vehicular Ad Hoc Networks (VANETs): Challenges and Perspectives, *Proc. of ITST 2006*, Chengdu, China.

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Over the past decade, there has been a prolific increase in the research, development and commercialisation of Wireless Sensor Networks (WSNs) and their associated technologies. WSNs have found application in a vast range of different domains, scenarios and disciplines. These have included healthcare, defence and security, environmental monitoring and building/structural health monitoring. However, as a result of the broad array of pertinent applications, WSN researchers have also realised the application specificity of the domain; it is incredibly difficult, if not impossible, to find an application-independent solution to most WSN problems. Hence, research into WSNs dictates the adoption of an application-centric design process. This book is not intended to be a comprehensive review of all WSN applications and deployments to date. Instead, it is a collection of state-of-the-art research papers discussing current applications and deployment experiences, but also the communication and data processing technologies that are fundamental in further developing solutions to applications. Whilst a common foundation is retained through all chapters, this book contains a broad array of often differing interpretations, configurations and limitations of WSNs, and this highlights the diversity of this ever-changing research area. The chapters have been categorised into three distinct sections: applications and case studies, communication and networking, and information and data processing. The readership of this book is intended to be postgraduate/postdoctoral researchers and professional engineers, though some of the chapters may be of relevance to interested masterâ€™s level students.

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