USING SMART DUST IN TRANSPORT DOMAIN

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ABSTRACT. The smart dust concept has been around for almost a decade now, but its application in transport domain has only been recently investigated. This is a very valuable area of research, as smart dust – being generally perceived as the low-cost, ubiquitous sensor of the future – can play an important role in Intelligent Transportation Systems (ITS). Our involvement in several transport-related UK and EU funded projects (such as ASTRA [1], EMMA [5], and TRACKSS [7]) gave us the opportunity to carry out feasibility experiments and to develop demonstrations of smart dust applications in transport domain. We have also investigated how smart dust can be used in collaboration with other (more traditional) transport sensors for developing better Co-operative Transport Systems (CTS). This position paper outlines what we have learnt from using smart dust in transport domain, and provides an illustration on the important role that the smart dust technology can play in future ITS.

WHAT IS SMART DUST?

Smart dust is a network of micro-electro-mechanical devices (also known as *motes*), which are typically composed of a processing unit, some memory, and a radio chip, which allows them to communicate wirelessly with other smart dust devices within range. This wireless capability makes it possible for smart dust devices to form a Mobile Ad-hoc NETwork (MANET) – a collection of mobile computing devices which cooperate to form a dynamic network without using fixed infrastructure. These devices can also be equipped with additional sensors – such as those for detecting light, temperature, barometric pressure and acceleration – hence enhancing their features and making their application areas virtually limitless.

There are various smart dust devices available on the market; we use off-the-shelf MICA family motes from Crossbow Technologies, in particular the MPR2400 MICAz motes [4]. These MICAz motes are equipped with a Zigbee radio chip [10], which enables them to communicate with other MICAz motes or other Zigbee-ready devices within range (approximately 70 meters). Figure 1 shows the main components of the MPR2400 MICAz mote.

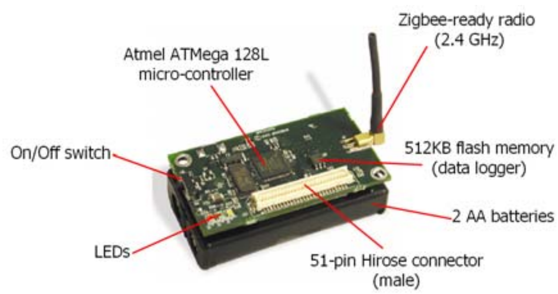

Figure 1: MPR2400 MICAz mote

One of the main questions that we had to address before using these motes in ITS applications is whether the Zigbee radio can be used for communication between motes placed in vehicles moving at high speed (over 100 km/h) and static motes on the road side. To answer this question, we carried out several experiments, the details of which can be found in [1] and [6]. In the end, we established that this can indeed be achieved, and we estimated the communication range to be around 50 metres. Based on these encouraging results, we designed and developed several ITS applications involving smart dust, in collaboration with other sensing technologies used in the TRACKSS project [7].

SMART DUST APPLICATIONS IN TRANSPORT

As part of the work carried out in TRACKSS project, we developed three collaborative scenarios involving smart dust and the following sensors (information regarding the TRACKSS partners can be found in [7]):

- Optical Identification Sensor (developed by LIVIC-LCPC, France)
  The main purpose of this collaboration is to combine the positive features of the optical identification sensor (good detection range and localisation feature) with those of the smart dust (freedom from visual

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impairment and customisable information passing) in order to create more reliable Infrastructure to Vehicle (I2V) applications. In this collaboration, two applications were developed (further details can be found in [2] and [9]):

a) *Road sign recognition application*. In this application, road signs are equipped with optical identification emitter and smart dust broadcaster (each sends an information corresponding to the road sign), the signals of which are picked up by the receivers on board the vehicle. This allows drivers to be aware of the road signs ahead, even in poor visibility or inclement weather conditions.

b) *Cooperative traffic light application*. This is similar to the road sign application above, but the signal contains information on the current traffic light colour and the time remaining on that colour.

- Ice Detector (developed by CRF-Fiat, Italy)
  In this collaboration, we obtain the information regarding ice on the road from a select few of vehicles equipped with the spectral analysis ice detector (which is still very expensive to purchase at the moment), and these vehicles broadcast the information to the road side "monitoring posts", which in turn can pass the information to the traffic control centre or other vehicles in surrounding area. This Vehicle to Infrastructure (V2I) application allows critical information regarding road conditions to be shared with the authority, as well as with other road users.

- Laser Scanner (used by ITACA, Spain)
  This collaboration allows information on light intensity (obtained by smart dust sensor using the standard sensor board) to be passed to the laser scanner. The laser scanner (which, among others, is used to measure traffic flow) is prone to erroneous reading due to intense light conditions, hence the information obtained from smart dust can be used to adjust their readings, hence obtaining more reliable results.

These applications had been successfully demonstrated at the TRACKSS project final review held in October 2008. We envisage further work to be carried out in Vehicle to Vehicle (V2V) applications; in more detailed investigation regarding the mote's Zigbee communication characteristics when travelling at high speed and in various traffic situations; as well as in using the motes en masse in order to create real MANET environment.

CONCLUSIONS

This paper has outlined some preliminary research, along with several applications that have been developed in order to demonstrate the feasibility of using smart dust devices (motes) in ITS. Initial results suggest that both the motes and the conceptual MANET can support both I2V and V2I communications. This illustrates that efficient and discrete ITS applications involving vehicle and infrastructure can be designed and developed using these motes. As the unit cost of motes will continue to go down, it will become financially feasible to deploy them in large numbers. This, coupled with other emerging technologies, highlights the opportunity to move towards a much more connected world for the traveller, where vehicles, the infrastructure and the traveller itself are much more connected together. Based on the encouraging results obtained from our applications, we have highlighted smart dust's potentials in transport domain, and if supported and developed in the correct way, this will eventually offer a steep change in how we manage, sense and operate our transport networks of the future; and this is a significant contribution that smart dust can make to the ITS domain.

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