**BIBIÁNA BUKOVÁ**, D. Sc.
E-mail: bibiana.bukova@fpedas.utc.sk
**ZUZANA ŠVECOVÁ**, B. Eng.
E-mail: zuzana.svecova@fpedas.utc.sk
University of Žilina, Faculty of Operation and Economics of Transport and Communications
Department of Railway Transport
Univerzitná 8215/1, 010 26 Žilina, Slovak Republic

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# USING SMART DUST IN TRANSPORT SERVICES

*ABSTRACT*

*Smart dust utilization is a futuristic concept that considers the usage of equipment called smart dust in the railway transport. It appears from the technology of the near future, whose basis are tiny sensors able to collect, process and wirelessly transfer information. The main idea of this technology is the possibility, in a certain space (for example inside the wagon) to recreate hundreds of tiny sensors that are designed to sense, measure and transmit data like temperature, humidity or the power of frequency of vibrations, so they would allow detection of some devices, people manner in some space or detailed check of a given surrounding.*

*KEY WORDS*

*device, smart dust, mote, monitoring*

## 1. INTRODUCTION

Originally part of a larger project funded by the U. S. Department of Defense central research and development group, Defense Advanced Research Projects Agency (DARPA), the Santa Clara, Calif. -based chip making giant has worked with the University of California, Berkeley- Kris Pister and Randy H. Katz- to create cubic millimetre-sized sensors, or "motes." Microelectromechanical sensor (MEMS), which is the base of smart dust, is called mot. First prototypes of mot were not like dust, their size was approximately 100mm$^3$. Therefore, they were called macro motes. The technology was tested with the macro motes and is fully functional. Current motes are about 4mm$^3$ in size and the researchers' goal is to get these chips down to 1mm on a side, to be like the grain of sand though each would contain sensors, computing circuits, bidirectional wireless communications technology and a power supply. Motes would gather scads of data, run computations and communicate that information using two-way band radio between motes at distances approaching 250 meters.

Devices called smart dust are able to:
- communicate wirelessly with the surroundings,
- communicate wirelessly among each other,
- create distributed network.

The motes create together one big network, which is able to evaluate the situation on high-level and then send processed analyses to the information system.

## 2. BASIC COMPONENTS OF SMART DUST

Current motes are about 4mm3 and this really small space contains all the devices needed for its functioning.

The basic components of the mot are sensors. They collect information about temperature, humidity, intensity of light, vibrations and air pressure. In the future other types like sensors for sound and video will be added.

Microprocessor serves for processing of information obtained by sensors of the mot as well as by communication device. The memory SRAM saves the program for microprocessor and transferred or detected data.

Communication with other motes or the main device proceeds by a sophisticated communication device.

The device also needs power supply and batteries.

## 3. FUNCTION AND COMPONENTS OF SMART DUST

The device is able to perform the function which is determined by types of sensors installed in it and by the type of program saved in the microcontroller. Mot is created to save the power. Mot is almost 99% in stand-by mode and only 1% of the time it performs its activity. Timers count the time which has elapsed from a particular activity of the mote. When the timer reaches the zero value, it starts the appropriate part of

the mot. It could be communication channel, sensor, analogue-digital converter or microprocessor. The given device, after having ended its activity, sets the timer to a given value. This is the working principle of the mot. In stand-by mode the device obtains the energy.

Sensors scan the values of physical quantity from the space and send them to the analogue-digital converter, where they are converted to the digital form and saved to the memory SRAM. The microcontroller analyzes them and determines what to do with them: delete, archive or send a notice. The microcontroller can also receive a new program through the communication channel, so that it is possible to program the device for new type of tasks.

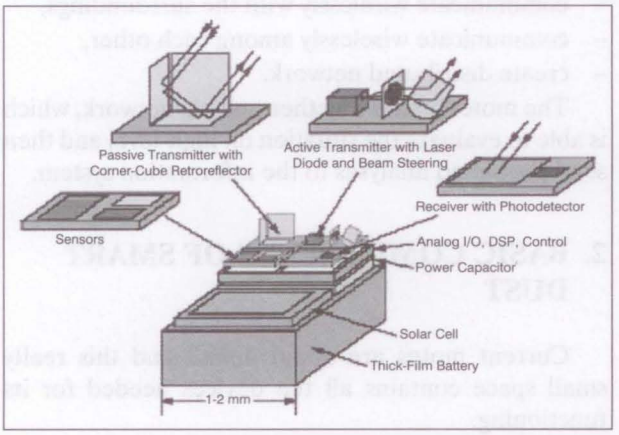


Figure 1 - Multifunctional mote

The battery is able to save the energy with the grossness 1J for $1mm^3$. Because of the small size of the mot, its capacity is very small. Researches want to minimize the power drain of the particular components of the mot. Apart from the battery, another power source is solar collector, which is able to supply energy by sunlight but also in the room. Another way is a little bit unconventional: the mot can supply energy from the change of air pressure from quake. Due to this fact, it can have a lifetime of several years.

Very interesting is the communication channel. It can use a ray of light for data transport, because it is more useful than using radio communication. Every mot has the light emitter, which has micro mechanic controlled mirror, so it can relay to arbitrary direction. Another communication device is passive but its function is not only to receive but also to relay information. The major system relays a ray of light towards the mot and the mot modulates information to it and then, through the use of mirror system reflects it back. The mirror system is made of three square mirrors placed at the right angle, so we can compare it to a corner of a room. The ray of light is in this way reflected to the same direction from which it came. By minimally moving one of the mirrors it is possible to modulate the information to the ray. Such system of communication is very effective, whereas when using macro motes transfers of 20 kilometres were made.

## 4. SMART DUST UTILIZATION

For smart dust there are a lot of potential commercial applications at present, so it can be used in different areas of our lives. It can be also used in the military sphere and in espionage. In the field of transport, logistic and forwarding, the applications include:

- weather/seismological monitoring,
- using of sensors in the packing - for example at automatic stock-taking in a stock,
- monitoring of vehicle and commodity movement,
- monitoring of vehicle parameters in all types of transport,
- monitoring of traffic at frequented communications,
- detection of errors at manufacturing via vibration trapping, which are outside the given range,
- monitoring of the clients in company,
- as part of technology of the so-called intelligent buildings – by simple addition to the building coat - by means of smart dust it would be possible to collect information about the state of the building and to manage it,
- monitoring of the power drain in companies which could help to reform power sources management,
- monitoring of the surrounding – for example smart dust can be pulverized round chemical and atom manufactures and its main task would be to inform immediately about a possible accident.

Smart dust can also be used as protection against theft and forfeit and provision of security at stocking or transportation. It is very difficult to spring smart dust. It is possible to dust it over a huge territory and observe the movement of people, or focus on small space of the bureau or stock. It need not be installed, you can only dust it.

This concept is applied and this system is used in the railway transport.

### 4.1. Smart dust utilization in railway freight transport

Dust of smart dust (the condition is: dusting in enclave) in:

- wagon,
- container,
- swap body.

Smart dust utilization is considered mostly in dispatches which involve increased attention - transportation in special conditions:

- transportation of perishable goods,
- transportation of animals,
- transportation of dangerous commodities,
- transportation of valuable dispatches.

### 4.2. Smart dust utilization at transportation of perishable goods

Perishable goods are commodities which deteriorate fast and which require individual precautions during the railway carriage, to be sheltered from cold or warm impact. So the perishable goods require during transportation icing, aerating, fumigation or other protection against cold or warm impact.

Smart dust has the following functions in the wagon:

- monitoring of humidity, temperature, vibrations, dust, aeration,
- distant regulation of temperature, humidity, as necessary,
- protection of delivery against abstraction,
- signalization of technical malfunction of refrigeration, freezing, or warming equipment,
- signalization of inconvenient conditions for the given transportation.

### 4.3. SMART DUST UTILIZATION IN ANIMALS TRANSPORTATION

Transportation of animals is specific because it involves individual precautions of transportation.

Smart dust inspects the setting of wagon, in which the animals are transported:

- diagnostics of airing,
- monitoring of humidity and temperature,
- diagnostics of wagon sanctity during transportation,
- diagnostics of animal health,
- snapping of animal kill,
- signalization of setting defiance,
- distant regulation of temperature, humidity according to weather as necessary.

### 4.4. SMART DUST UTILIZATION IN DANGEROUS COMMODITY TRANSPORTATION

- monitoring of setting changes inside the wagon,
- signalization of unexpected changes of the settings which could have adverse effect on the transported dangerous commodity,
- monitoring of physical states (temperature, humidity, vibrations), which could affect adversely the transported dangerous commodity,
- signalization of emergency conditions,
- diagnostics of wagon sanctity during transportation.

### 4.5. SMART DUST UTILIZATION IN VALUABLE DISPATCH TRANSPORTATION

Valuable delivery is a delivery which has high financial value, possibly has other values (personal, artistic, historical, etc.). Smart dust is used there for security, but also provides other monitoring if necessary.

Utilization:

- monitoring of setting inside of wagon, container or swap body,
- signalization in specific situations (damage of traffic or transportation vehicle),
- signalization of unexpected change of setting,
- if it is a delivery transported under specific conditions then monitoring of specific functions.

## 5. CONCLUSION

"Smart dust" devices are tiny wireless microelectromechanical sensors (MEMS) that can detect everything from light to vibrations. Thanks to recent breakthroughs in silicon and fabrication techniques, these "motes" could eventually be the size of a grain of sand, though each would contain sensors, computing circuits, bidirectional wireless communications technology and a power supply. Motes would gather scads of data, run computations and communicate the information using two-way band radio between motes at distances approaching 300 meters.

Potential commercial applications vary, ranging from identifying manufacturing defects by sensing out-of-range vibrations in industrial equipment to tracking patient movements in a hospital room. Smart dust can find a wide area of utilization in the railway transport as well.

**BIBIÁNA BUKOVÁ**, D. Sc.
E-mail: bibiana.bukova@fpedas.utc.sk
**ZUZANA ŠVECOVÁ**, B. Eng.
E-mail: zuzana.svecova@fpedas.utc.sk
Žilinská univerzita
Fakulta prevádzky a ekonomiky dopravy a spojov
Univerzitná 8215/1, 010 26 Žilina, Slovenská Republika

*ANOTÁCIA*

*VYUŽITIE INTELIGENTNÉHO PRACHU V PREPRAVNÝCH SLUŽBÁCH*

*Využitie inteligentného prachu je návrh futuristický, uvažuje s možnosťou využitia zariadenia označovaného ako inteligentný prach (smart dust) v železničnej preprave. Vychádza z technológie blízkej budúcnosti, základom ktorej majú byť*

*miniatúrne senzory schopné zberu, spracovania a bezdrôtového prenosu informácií. Hlavnou myšlienkou tejto technológie je možnosť rozptýliť v nejakom priestore (napríklad vo vnútri železničného vozňa) stovky miniatúrnych senzorov, ktoré by merali teplotu, vlhkosť alebo silu či frekvenciu vibrácií a tým by umožnili sledovať určité zariadenia, správanie ľudí v nejakom priestore alebo detailne kontrolovať dané prostredie.*

***KĽÚČOVÉ SLOVÁ***

*inteligentný prach, sledovanie, zariadenie , mot*

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