„Internet of Things and Wireless Sensor Networks“

Dusan Bevc, Invento Ura

ICON‘S ROUNDTABLE:
„HOW MUCH KNOWLEDGE IN ONE CUBIC CENTIMETER? „
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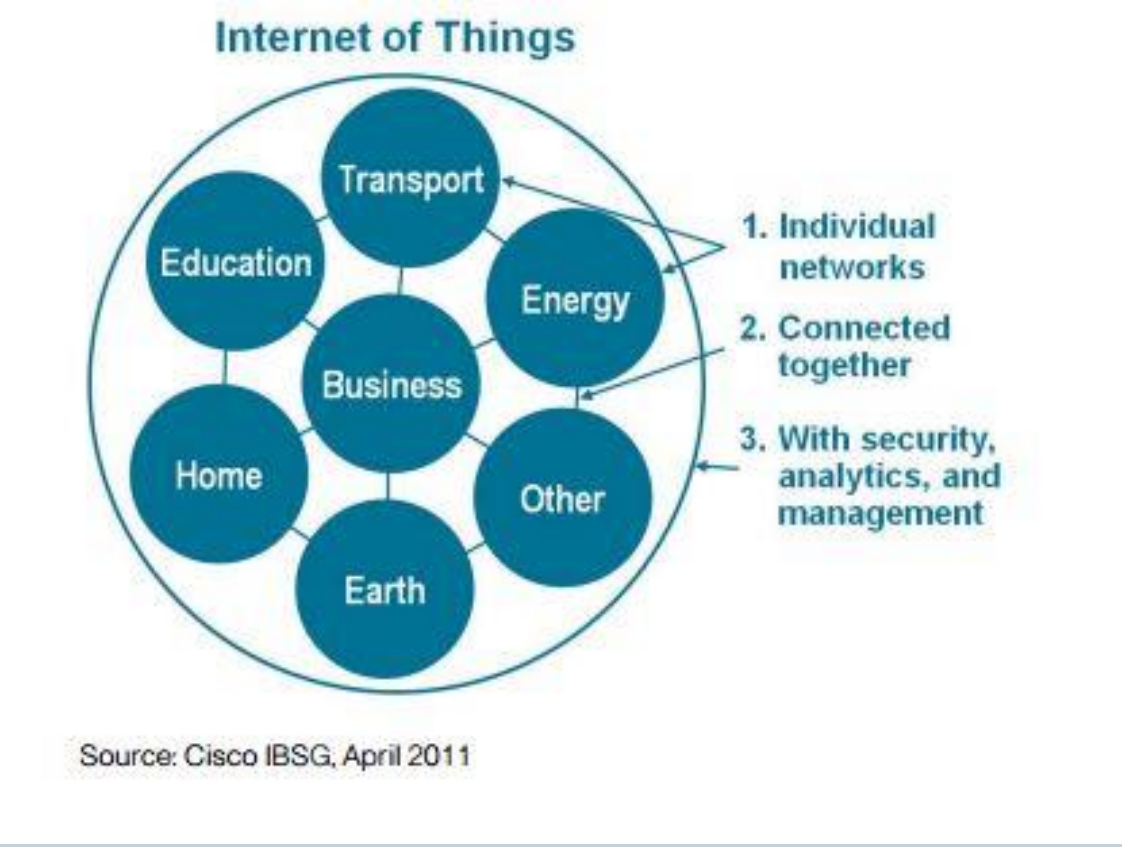
IoT - Interconnected World



Internet of Things - IoT

The vision of the „Internet of Things“ is to attach tiny devices to every single object to make it identifiable by its own unique IP address. These devices can then autonomously communicate with one another.

Source: Financial Times

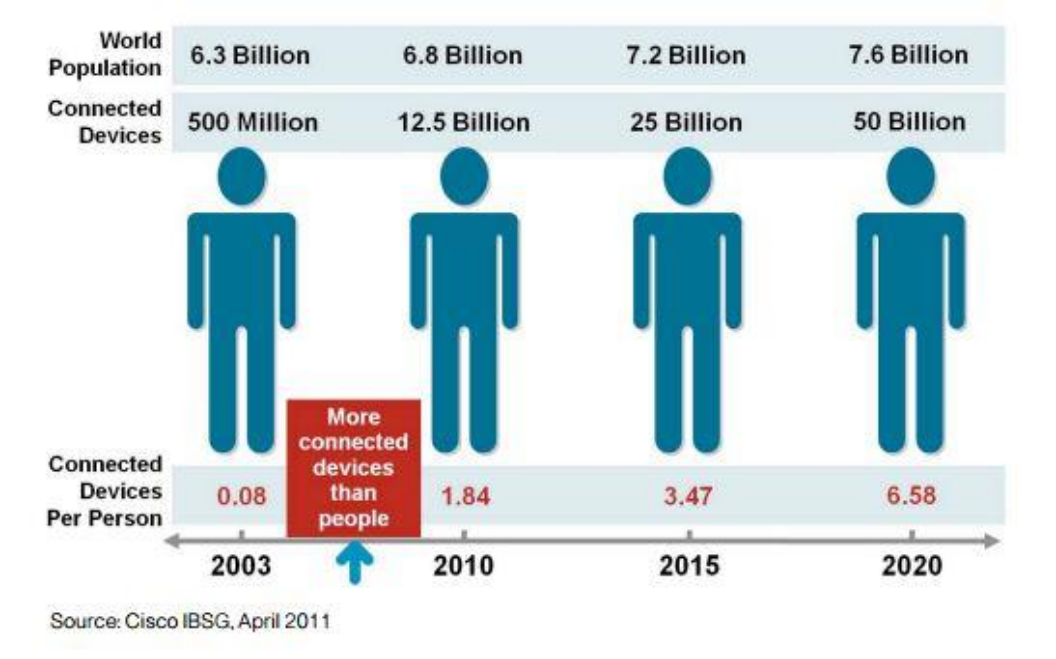
Internet of Things is the point in time when more „things or objects“ were connected to the Internet than people.

Source: Cisco

The Internet of Things is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment.

Source: Gartner

IoT was „born“ between 2008 and 2009



Maybe IoT is still a vision?

Building and deploying an IoT system will be challenging due to current issues of IT heterogeneity, global distribution of devices, scale, management and security. Questions such as how an IoT system will automatically perform firmware upgrade operations for millions of on-line and off-line devices; and how an IoT system will proactively identify security risks and take proper actions, remain to be answered.

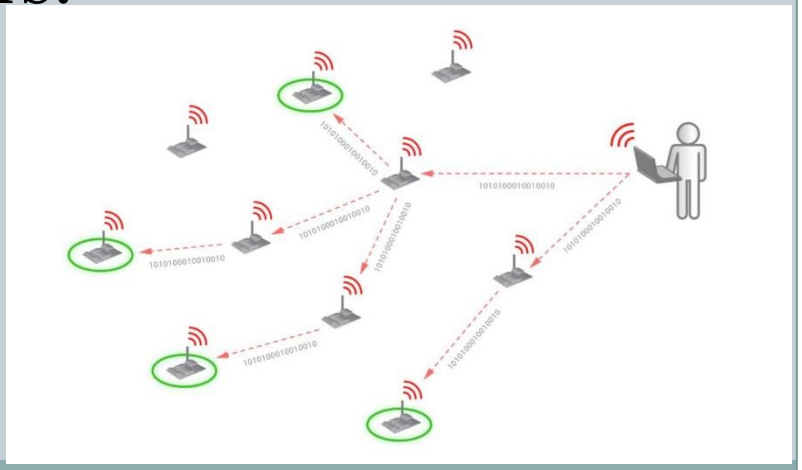
Source: IBM 2011

Key Enablers for IoT

- Availability of IP addresses
  - IPv6 started in 2012, allowing 3,4 x 10^{38} addresses
- Miniaturization of Wireless Sensor Networks (WSN)
  - Miniaturization of sensors
  - Energy harvesting technologies
  - Lower energy consumption of electronics
  - Standardization
- Added value applications
  - Mobility

Wireless Sensor Networks (WSN)

- Eyes, ears, nose and skin of the „IoT“
- Collect surrounding context and environmental information
- Comprised of mesh of nodes (MOTES) capable of communicating between each other or with sink
- Already many deployed sensors:
  - Mobile phones
  - Surveilance cameras
  - GPS receivers
  - Motion and light sensors

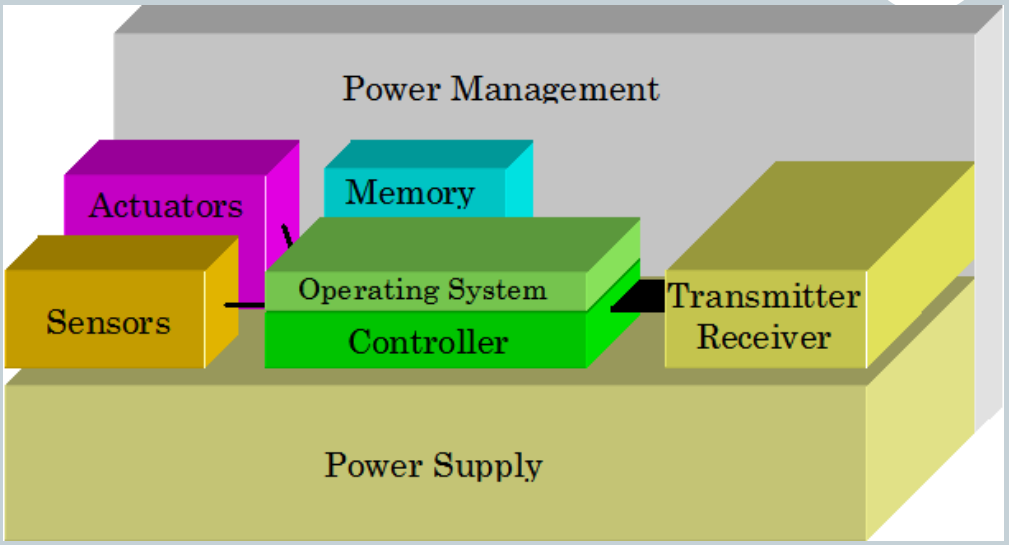


Why are WSN so attractive today?

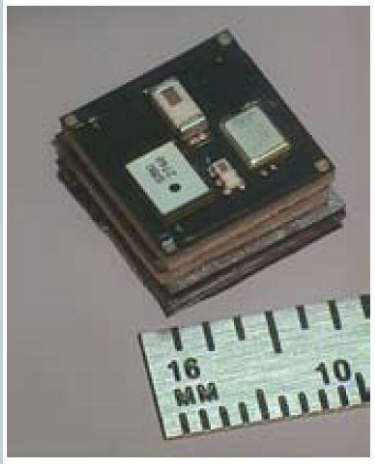
Technology enablers:

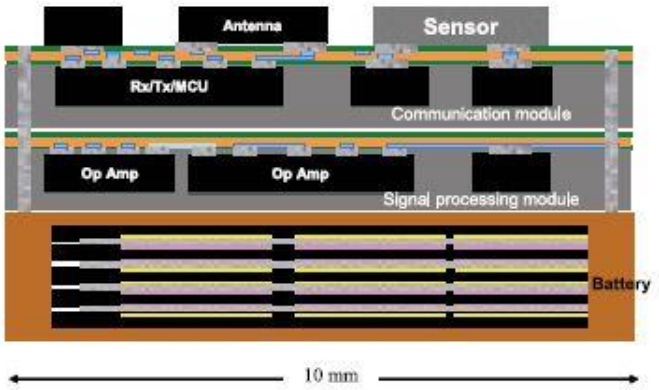
- CPU performance with low power requirements and smaller size – Moore‘s law
- New low power sensors for physical, chemical and biological sensing tasks
- Transceivers for WSN devices are smaller, less expensive, and with lower energy consumption
- New energy sources: high capacity rechargeable batteries, energy harvesting solutions
- Beginning of standardization

MOTES Structure

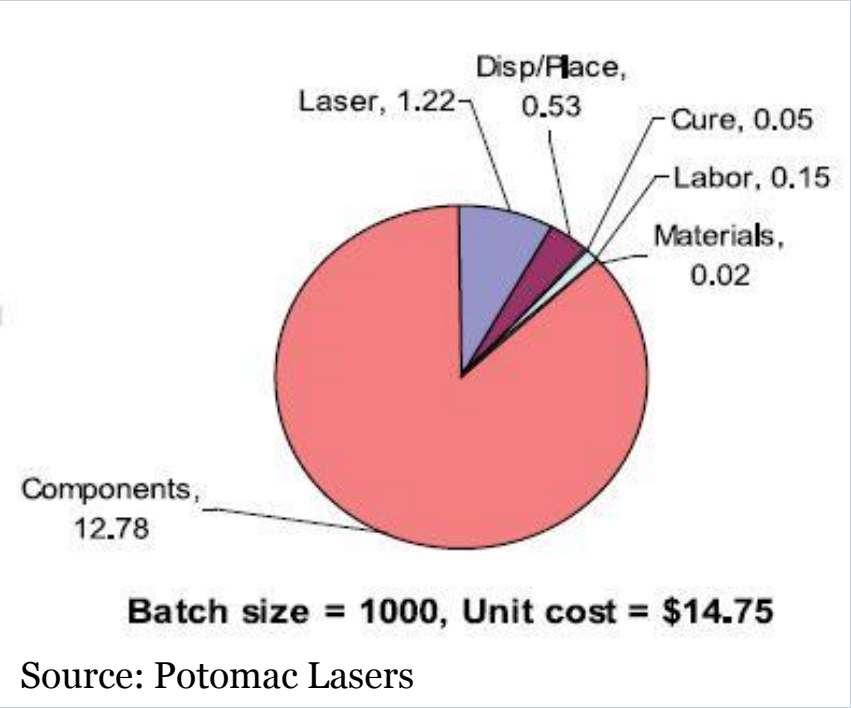


- Almost the same configuration as in a DVD player
- Size can vary from shoe box to sugar cube or even smaller





Low Hardware Costs of MOTE



Source: Potomac Lasers

Despite commercial availability of ready-made MOTES are strong tendencies for custom design and fabrication; mainly because:

- Prices of commercial MOTES are relatively high
- No universal MOTE for all applications
- New technologies for small scale fabrication (printed electronics, rapid prototyping, etc.)

WSN is Clearly Disruptive Technology

WSN Node Hardware	PCB	Low power design	SMD		
		Multilayer	Polymer	Line width	< 200 microns
					< 20 microns
					Other
			Ceramic	Line width	< 200 microns
					< 20 microns
					Other
			Laminate	Line width	< 200 microns
					< 20 microns
					Other
		Reconfigurable HW & SW	FPGA		
			Other		
	Energy supply	Batteries	Specify		
		Batteries charging	Low voltage charging		
			High voltage charging		
		Energy harvesting	RF		
			Vibrations		
			Solar		
			Temperature Gradients		
			Human Power		
			Wind flow		
			Other		
		Antenna design	Customization		
			Miniaturization		

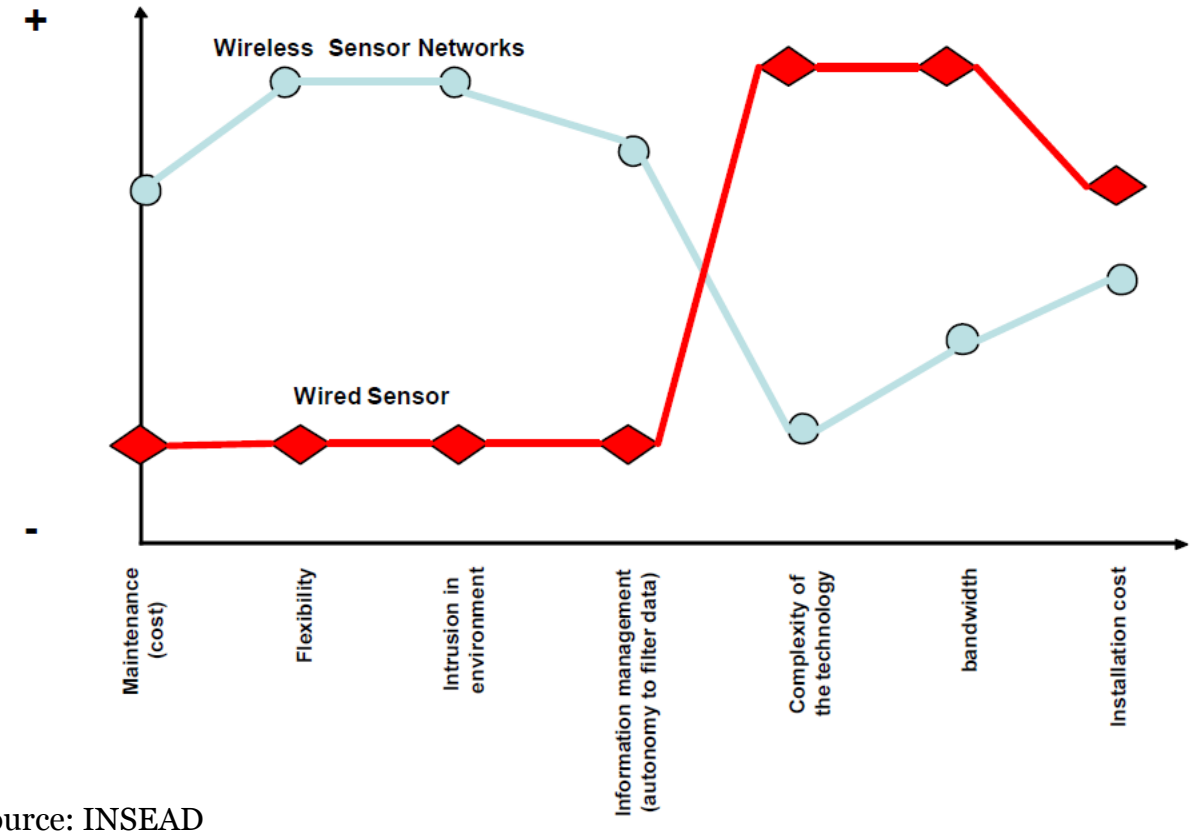
WSN Node Software	Operating system	TinyOS
		Contiki
		LiteOS
		Mantis
		Other
	Programming Language	Specify
	Remote Reprograming of WSN Nodes	Specify
	Data Mng. & Querying Languages	Tiny DB
		COUGAR
		SINA
		Other
	Communication SW	Specify
	Security SW	Specify
	Integration with IP Networks	
	Integration with Celllular Networks	
	Data Mining Capability	
	Big Data Storage & Access	

Miniature Sensors	Temperature
	Vibration
	Location
	Motion
	Pressure
	Video
	Humidity
	Gases
	Bio - sensors
	Chemicals
	Other

WSN is NOT:

- Network of miniaturized traditional computers
- Network of uniform WSN sensors
- Single purpose network
- TCP/IP network

Wireless vs. Wired - Value Curve



Source: INSEAD

Many Applications with Scalability Potential

- Environmental/habitat monitoring
- Sensing physical conditions (temperature, sound, vibration, pressure, location, movements)
- Disaster management
- Inventory management systems
- Intra-vehicular networks
- Intelligent transport
- Smart parking
- Detection and mapping of subsurface infrastructures (pipelines,..)
- Intelligent buildings
- Weather and tidal surge predictions
- Industrial process control
- Large scale metrology
- Interactive video/computer games

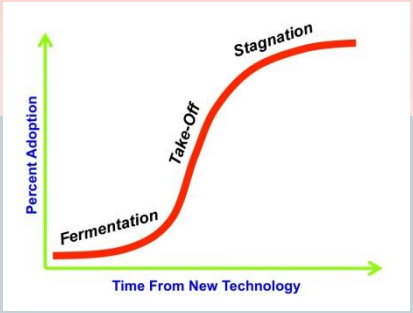
Source: IHS Goldfire

- Surveillance of manufacturing devices
- Fire hazard detection
- Fitness trainee monitoring
- Precision agriculture
- Medical monitoring
- Home automation
- Real time tests
- Machine health monitoring
- Harsh environment monitoring
- Surveillance and intrusion detection
- Lighting systems
- Security systems
- Natural resource management
- Smart Grids
- Structural integrity monitoring
- Smart metering

Fragmented Innovations with some Key Players

Assignee	No. of Patents	Activity Trend
Patents assigned to individual persons or to no Assignee	735	Accelerating activity between 2002 and 2012
Electronics and Telecommunications Research Institute	126	Accelerating activity between 2007 and 2012
KONINKLIJKE PHILIPS ELECTRONIC NV	113	Accelerating activity between 2005 and 2012
Honeywell International Inc.	110	Accelerating activity between 2005 and 2012
International Business Machines Corp.	89	Accelerating activity between 2002 and 2012
SamSung Electronic Co. Ltd.	88	Accelerating activity between 2005 and 2012
Fujitsu Ltd.	77	Accelerating activity between 2004 and 2012
Robert Bosch GmbH	68	Accelerating activity between 2006 and 2012
Hitachi, Ltd.	55	Declining activity between 2004 and 2012
NEC Corp.	50	Declining activity between 2004 and 2012
コーニンクレッカ フィリップス エレクトロニクス エヌヴィ	47	Accelerating activity between 2007 and 2012
SAP AG	47	Accelerating activity between 2006 and 2012
Motorola, Inc.	45	Accelerating activity between 2002 and 2012
NTT DoCoMo, Inc.	42	Declining activity between 2004 and 2012
Microsoft Corp.	36	Accelerating activity between 2005 and 2012
Siemens AG	34	Declining activity between 2009 and 2012
Intel Corp.	30	Accelerating activity between 2003 and 2012
Matsushita Electric Ind. Co. Ltd.	26	Accelerating activity between 1995 and 2008

- Total approx. 1700 patents for WSN
- Key ICT companies involved in WSNs
- High number of patents from individuals
- Very broad spectrum of patent fields
- Early stage at S-Curve



Source: IHS Goldfire

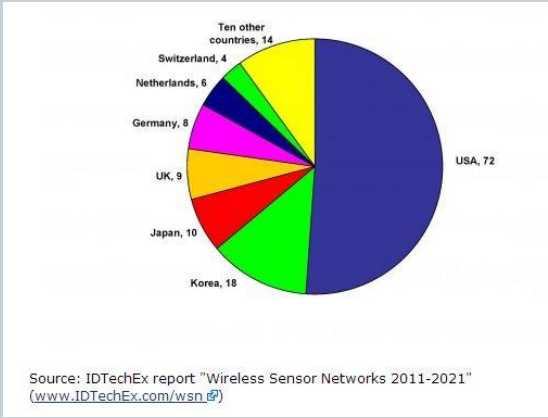
No Universal MOTE for all Applications

- Heterogeneous MOTEs shall prevail
- Wired MOTEs with expensive sensors and high power requirements.
- Few sensors attached to single MOTE
- Functional modularity of MOTEs
- High lifetime MOTEs shall prevail (long life batteries, efficient energy harvesting)
- Bandwidth shall remain bottleneck. Processing of measured data shall be performed in MOTE.
- Smart Sensing ➡ Sensing for Smartness

High Market Growth Potential

- Compound average growth rate (CAGR) of 15 % predicted from 2012 to 2017 to reach $3,8 billion.*
  Source: Marketsandmarkets, August 2012
- ZigBee growth 10 times from 2007 – 2010. In 2011 45 million shipments. Smart metering was key application.* Source: ABI Research, September 2012
- WSN mesh networks (smart meters) to grow from $0,45 billion in 2011 to $2 billion in 2021. *

Source: Energy Harvesting Journal, August 2011



Main Current Obstacles

- Lack of standards – there is no single standard as clear winner
- Lack of total solution – big success is within offering complete applications
- Network security issues- insertion of false information
- On-line and off-line upgrades
- Price still too high
- Lifetime of nodes not long enough – battery issue
- Miniaturization not yet on required level for some major applications.

WSN - Technology Enabled & Application Driven

- Power generation, storage and management is critical technology path
- No universal MOTE leads to small production quantities.
- Limited scalability – WSN networks with up to few 1.000 MOTES.
- Limited Economy-of-Scale. What is going to reduce costs?
- Modular design of MOTES – Who is going to be MOTEs integrator?
- System integration – single or multiple HW sources ?
- Some solutions have business scalability potential.
- Data fusion & management, knowledge expert systems are „Big game“ (cognitive experts systems, semantic engines, behavioral predictions, artificial intelligence)

Conclusions:

1. IoT and WSN are the most interesting area of research and marketing analysis in the past years
2. Fusion of many existing and new technologies
3. Technology enabled & applications driven business
4. Ideal business segment for:
    1. Risk sharing cooperation
    2. Competitive bidding and integration
    3. Collaborative research
    4. Specialisation
5. Business opportunity for micro, small, medium and large companies.

Thank you for your attention.

Dusan Bevc
INVENTO URA
Ulica 25. maja 42
6258 Prestranek, Slovenia
E-Mail: dusan.bevc@siol.net
Phone: +386 41 61 55 89