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SIGNIFICANCE OF NANOTECHNOLOGY FOR FUTURE WIRELESS DEVICES AND COMMUNICATIONS

Arfa Quamar, Apoorva Arya, Alka pandey
Electronics And Communication, Dronacharya College Of Engineering

Abstract- **Nanotechnology is the art and science of manipulating matter at the nanoscale (down to 1/100,000 the width of a human hair) to create new and unique materials and products...with enormous potential to change society. This paper reviews the expected wide and profound impact of nanotechnology for future wireless devices and communication technologies.**

I. INTRODUCTION

One of the central visions of the wireless industry aims at ambient intelligence: computation and communication always available and ready to serve the user in an intelligent way. This requires that the devices are mobile. Mobile devices together with the intelligence that will be embedded in human environments – home, office, public places – will create a new platform that enables ubiquitous sensing, computing, and communication. Mobility also implies limited size and restrictions on the power consumption. Seamless connectivity with other devices and fixed networks is a crucial enabler for ambient intelligence systems – this leads to requirements for increased data rates of the wireless links. Intelligence, sensing, context awareness, and increased data rates require more memory and computing power, which together with the size limitations leads to severe challenges in thermal management. All these requirements combined lead to a situation which can not be resolved with current technologies. As we see in the rest of the paper and in other literature ,nanotechnology could provide solutions for sensing, actuation ,radio, embedding intelligence into the environment, power efficient computing ,memory, energy sources ,human–machine interaction ,materials, mechanics, manufacturing, and environmental

Issues. Nanotechnology is a field of science and technology of controlling matter on a scale between 1-100 nanometer.

II. SENSORS AND SENSING EVERYWHERE

Micromechanical sensors became an elementary part of automotive technologies in mid1990, roughly ten years later more miniaturized micromechanical sensors are enabling novel features for consumer electronics and mobile devices. Within next ten years the development of truly embedded

sensors based on nanostructures will become a part of our everyday intelligen tenvironments. Nanotechnologies may also augment the sensory skills of humans based on wearable or embedded sensors and the capabilities to aggregate this immense global sensory data into meaningful information for our everyday life. This requires novel technologies and cross-disciplinary research in many ways.Embedding intelligent and autonomous devices into physical objects of the world requires that devices adapt to their environment and become a part of the network of devices surrounding them. There is no way to configure this kind of a huge system manually – top down. Nanotechnology can help to develop novel kind of intelligent devices where learning is

one of the key characteristic properties of the system,similarly to biological systems which grow and adapt to the environment autonomously.Nanotechnologies may open solutions for sensors that are robust in harsh environmental conditions and that are stable over long period of time. Today mechanical sensors – pressure and acceleration sensors – are already demonstrated to fulfil these requirements, but we do not have chemical or biochemical sensors that are stable or robust enough. Furthermore, the future embedded sensors need to be so inexpensive and ecologically sustainable that they can be used in very large numbers.Driverfor nanotechnologies in sensors is not primarily miniaturization. The size of the sensor depends on measurement itself, and the sensors need to be packaged in an appropriate way to integrate them with measurement. Nanotechnologies will enable new materials and new sensing elements for sensors. It will become possible to create sensors that consist of huge arrays of similar sensing elements and thus develop novel sensing principles for example for chemical and biochemical sensors

III. SOLUTIONS FOR RADIO

RF operation in the GHz frequency range brings challengesnot only with range and interference avoidance, but also with processing speed. The radio frequency determines the basic
clock speeds and sets requirements on how often certain physical and medium access control layer signal processing algorithms need to be run per second. Here nanotechnology
could help. For example, recent advances in nanotechnology and scaling allow building of systems with a large number of nanoscale resonators, e.g., NEMS devices which could beca use for GHz signal processing applications. This type of a system can make spectral processing in RFdomain feasible. This is of special importance for high data rate wireless communications systems. One particularly important application would be spectral sensing in mobile
devices with flexible spectrum use and/or cognitive radio features. There wide radio spectrum bands need to berepeatedly scanned in real-time with low power consumption.
In addition, a lot of processing speed and power is needed toanalyze the data and run all the algorithms which enable intelligent use of spectrum and fast adaptation to dynamically changing radio environment.With current technologies only limited versions of fully cognitive applications could be
realized, in particular when operation frequencies are in the
GHz range. Another interesting application is wireless ad-hoc networks with large number of extremely low-cost, low-power
elements. For example, all the required components of awireless sensor node, i.e., a sensing unit, a processing unit, a transceiver unit, and a power unit have already been
demonstrated with nanoelements, such as carbon nanotubes. However, a lot of work remains to make these components suitable for nanosize wireless sensor nodes, and to integrate them together into a complete system. Once realized, this could enable a vast number of novel applications and possibilities of ultra-low power wireless sensor networks that have not been possible before. In addition to communication networks and environmental sensors, also applications to medicine and healthcare can be significant. Nanotechnology also offers new possibilities for antennas. Reducing the size of current antennas made from magnetic and conducting bulk material increases electromagnetic dissipation. The antenna geometry can be optimized using numerical simulations, but the radical enhancement of the performance could come from nanotechnology: by tailoring new materials, e.g., magnetic nanoparticles, we can hope to reduce the losses and tune the electrical permittivity and permeability to optimal values. Another intriguing possibility is metamaterials, which exhibit physical properties not appearing conventionally in nature

IV. MORE SPEED, LESS ENERGY

Ever increasing wireless communication speeds require increasing amount of computation with limited power.Continued innovation has made it possible to follow the Moore's law and to provide electronics with all the time
Increasing performance with reduced price. The current approach of simply reducing the transistor size seems to come to an end by about 2015 due to the limitations of the
manufacturing technology . By 2020, the traditional silicon CMOS is expected to reach a density of 1010 devices per cm2,switching speed of 12 THz, circuit speed of 61 GHz, and switching energy of 3x10-18J [4]. This should be considered a
benchmark for new approaches based on nanotechnology.Such approaches include new materials leading to transistors with improved properties (for example Intel's recent announcement on metal gate high-k transistors and combination of new type of nanoelements with traditionalcircuits . Some circuitry can be replaced with application
specific nanosystems, either digital or analogue, tailored toperform a specific signal processing task with vastly improved power efficiency and speed. At the nanoscale the operation of the devices is more
stochastic in nature and quantum effects become the rule rather than the exception. It could easily be

that the current standard computation methods and models will not be optimal with these new devices and technologies. As an example, parallel computing with neural networks could be optimal for processing and understanding information from sensors. Other ideas being studied currently are, e.g., spintroni and cellular automata, realized with spin-based
systems of nanosize magnetic particles System design with these kinds of elements requires development of computing methods which are tolerant tofailing components, and capable to take into account quantum-scale effects inherent in nanosy

V. MORE MEMORY

Already today mobile phones require a considerable amount
of storage capacity to retain pictures, video, music, and data from a number of different applications. Taking into account wider usage of different tools allowing users to create their own content and fast wireless links for loading of external
content, we can easily expect that mobile phones will require up to 10 GB internal mass memory for short term and 50- 100GB for mid and long terms.Memories for mobile devices should meet very tough
requirements. Low power consumption is required for both
active and standby modes. Battery energy is limited (typically500-1500 mAh) and small factor of products have limited maximum heat dissipation (2-4 W) due to safety and
reliability. Low voltage is needed because of power limitations, battery voltage development, and system design. Currently 1.8 V core and I/O is a standard in the mobile industry, and we expect a transition to 1.2 V within 3-5 years.

VI. BETTER HUMAN - MACHINE INTERACTION

Form factors and user interface concepts of the mobile multimedia computers will vary according to the usage scenario. The tendency towards smaller and thinner structures as well as towards reliable transformable mechanics will continue. Curved, flexible, compliant, and stretchable structures together with the need for more freedom for industrial design set demanding requirements for the user interface technologies; displays, keyboard, and overall integration of the user interface. A possibility to integrate electronics and user interface functions into structural components, such as covers, will become necessity. Furthermore, the concepts of the future intelligent environments require novel means to interact with the smart spaces and to use the mobile personal device as a user interface in this interaction. Interaction paradigms become more intuitive to consumer, but much more complex to implement

VII. MORE POSSIBILITIES WITH NEW MATERIALS

Enhanced user experiences created via new, useful device features and functions, good design and usability, and attractive personalized look and feel are major drivers for the development of future communication devices. The wish to have high-performance devices with “all the features” in small, compact physical size and being easy to use and carry, sets high requirements for several technologies. Materials technology is in key role in the development of many areas such as device mechanics, core electronics, advanced user interfaces, displays, energy sources, and data storage, as discussed above

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