Internet of Nano-Things (IoNT): Enabling New Advancement via Nanotechnology

Internet of Things (IoT) Week
Date: 24th – 26th August 2015
Venue: MIMOS Berhad and Hotel Istana Kuala Lumpur.
Introduction: NanoMalaysia Bhd.

Phase development of nanotechnology
Worldwide trends & market in Nanotechnology

Commercialization through Jumpstart Sectors
Alignment with NKEAs of Economic Transformation Programme (ETP) & Commercialization Programs

Internet of Things (IoT) ecosystem and prospects
Underlying trends driving the new IoT ecosystem.

NanoMalaysia IoNT Programs
IoNT as an integrated solution: Enabling new advancement in Nanotechnology
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"Nanotechnology development would be given and be made of the resources of the country's new economic model. Thus, it is important for Malaysia to not be left behind in the field of nanotechnology and we have decided to give importance….”

YAB Dato’ Sri Mohd Najib Tun Razak
29 Oct 2009

NanoMalaysia Berhad (NanoMalaysia) was mooted during National Innovation Council (NIC) meeting, chaired by the Right Honorable Prime Minister, Y.A.B. Dato’ Seri Najib Tun Razak on 14 February 2011.

NanoMalaysia was then incorporated as Company Limited by Guarantee (CLG) in August 2011 under Section 24, Company Act 1965 to take the lead in commercialisation of nanotechnology products.

Key functions of NanoMalaysia:
- Plan and coordinate the commercialization of R&D in nanotechnology
- Strategize the positioning of nanotechnology industry of Malaysia
- Facilitate the development of human capital
- Plan and execute activities that contribute to the development of nanotechnology-based industries
- Commercialization and development of nanotechnology
- Facilitate investment in nanotechnology commercialization
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Network architecture of Internet of Nano-Things (IoNT)
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“The application of scientific knowledge to control and utilize matter in the **nanoscale** (1 nm to 100 nm), where properties and phenomena related to size or structure can emerge.”

Adapted from Roco, MC (2004) AI Che J. 50 (5)
ISO/TS 80004-1:2010
Worldwide Market Incorporating Nanotechnology

Market incorporating Nanotechnology dollar ($) vs. Years

- 1st Generation: Passive nanostructures
- 2nd Generation: Active nanostructures
- 3rd Generation: Nanosystems by design
- 4th Generation: Systems of Nanosystems

World annual rate of increase: ~ 25%

Final products incorporating nanotechnology in the world

Current position

~ $ 40B
~ $ 92B
~ $ 120B
~ $ 250B
~ $ 1T by 2015
~ $ 3T by 2020

Year

Sources:
- Deutsche Bank (2005)
- Lux Research (2009)

1. "The U.S. is once again the leader in corporate nanotechnology spending; increase of 19% 2015 to reach $4.1 billion."

2. "Seventh Framework Programme (FP7); The Nanosciences, Nanotechnologies, Materials, and New Production Technologies (NMP) sub-program runs 7 years $4.7 billion 65%: Nanotechnology"

"By 2018, Asia will emerge as a leading producer of nano-enabled products with more than $1 trillion in revenue, compared to in the U.S and Europe."

"Nanotechnology initiatives and development in Malaysia are aligned with the growing global revenues ($ trillions) of nano-enabled sectors"
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Commercialization through four (4) Jump Start Sectors

1. **Food & Agriculture**
   - Nanofiber, Nanocellulose (Forestry Nanotechnology, Filtration system)
   - Food processing and management (smart packaging)
   - Nano-encapsulation, Nanofertilizer (Bio-active ingredient detection and database)

2. **Electronics, Devices & Systems**
   - Nanosensors (Scalar sensors & system)
   - Nanoelectronics (Processors, NEMS)
   - Nanodevices (Phones, cameras etc.)

3. **Energy & Environment**
   - Li-ion battery anode / ultracapacitors (Power system)
   - Advanced materials (Nanogenerators, Nanochip)
   - Green energy and power technology (Sensors for alternative power sources)

4. **Wellness, Medical & Healthcare**
   - Drug delivery (Nanomedicine, biosensors)
   - Packaging and systems (Nanonetworks for healthcare applications, RFID)
   - Antimicrobial applications (Antimicrobial assays)

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- **Nanoparticles and Bionanotechnology Platform (wearables development)**
- **Nanowire: electronic devices and sensors**
- **CNT: Nanotechnology engineering and nanocomposite application**
- **Graphene: Nanotechnology engineering and nanocomposite application**
Alignment with NKEAs of Economic Transformation Programme (ETP)

1. **Food & Agriculture**
   - Incremental GNI by 2020: RM 29 billion
   - Additional Jobs by 2020: 109,335
   - **EPP Highlights**
     - High-value Herbal Products
     - Establishing Malaysia as a Global Biodiversity Hub

2. **Electrical & Electronics**
   - Incremental GNI by 2020: RM 53 billion
   - Additional Jobs by 2020: 157,000
   - **EPP Highlights**
     - Enabling industries through Nanotechnology
     - Increasing solar module producers
     - Enable EV component manufacturing

3. **Oil, Gas and Energy**
   - Incremental GNI by 2020: RM 131 billion
   - Additional Jobs by 2020: 52,300
   - **EPP Highlights**
     - Building up renewable energy and solar capacity
     - Increasing solar module producers

4. **Wellness, Medical & Healthcare**
   - Incremental GNI by 2020: RM 35 billion
   - Additional Jobs by 2020: 181,000
   - **EPP Highlights**
     - Creating supportive ecosystem to grow clinical research
     - Building up renewable energy and solar capacity
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Internet of Nano-Things Ecosystem and Prospects

The interconnection: New networking paradigm

A scalable approach to connect everything

Rapid growth of communication & technologies

Industry projections for Global Economic Value of the Internet of Nano-Things in 2020

[1] “The Internet of Nano Things (IoNT) is expected to grow from $4.26 billion in 2016 to $9.69 billion by 2020”

[2] “The Internet of Things (IoT) and Advanced materials (nanotechnology) are potentially economically disruptive technologies by 2025”


Nanotechnology Attributes toward Internet of Things (IoT)

- **Miniaturization** (viable and smaller sensors, controllers and transmitters)
- **Highly advance material** (New technological devices/systems)
- **Wider network** (Increased capacity)
- **High performance** (Faster processors, better communication medium with denser memories)

Nanotechnology Driving New IoT Ecosystem

Towards Internet of Nano-things

Big Data Analytics

Direct Impacts of Internet of Nano-Things (IoNT)

- **Social**
  Complex networks
  Networking technology captures wider interaction

- **Environment**
  Waste to wealth
  Crafting value and concept toward environmental sustainability

- **Economy**
  Full value chain
  Social/people economy
Underlying Trends Driving The New IoT Ecosystem.

Moore’s Law
Number and length of transistors bought per $:
- 180 nm, 2002, 2.6 mil
- 130 nm, 2004, 4.4 mil
- 90 nm, 2006, 7.3 mil
- 65 nm, 2008, 11.2 mil
- 40 nm, 2010, 16 mil
- 28 nm, 2012, 20 mil
- 20 nm, 2014, 20 mil
- 16 nm, 2015, 19 mil

1. Economically viable sensors, controllers and transmitters
2. Huge demand for better & smaller microchips
3. Wider network availability and increased capacity
4. Commoditised hardware and cloud-based data management and storage
5. Development of new & powerful analytics and applications via new technologies

Adapted from ‘The Internet of Things is Now’, Morgan Stanley, 2014
The Communications Market Report’, Ofcom, 2014
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Overall Architecture of Internet of Nano-Things (IoNT)

A Interconnected office through network

- Nanonodes: Simplest Nanomachines: able to perform simple computation, limited memory, and can only transmit over short distances
- Nano-router: Larger computational resources: suitable for aggregating Information and control by exchanging simple control commands
- Nano-micro interface: Aggregate the information: converting conventional communication networks
- Gateway: Remote control of the entire system over the Internet: interface in our body/device to our healthcare/service provider

B Intrabody nano-networks for healthcare applications

- Service/Healthcare provider
- Micro-link
- Nano-link
NanoMalaysia IoNT Program 1: Transportation

- Nanostructured Energy Storage (Nano Battery/Ultracap & power monitoring & management system)
- Internal Control Network (Nano-Sensor & signalling system with Nano-Enhanced Electronics)
- Rubber Tires (Nano/Graphene enhanced tires provides lighter and mechanically stronger tires allowing the vehicle to cope with steeper grades, Nano-sensors for tire wear monitoring system)
- Antibacterial Internal Handrail & Seats (Nano-Anti-microbial technology, nano-silver coating)
- Integrated Rail System (Nano-Electronics & Mechanical system integration & interconnectivity for data management, big data analytics)
- Exterior (Nano/Graphene enhanced framework for lightweight rail cars enhanced by Integrated Nano Structural Batteries, Coatings & Performance Monitoring System)
- Internet of Things (IoT) solutions
- Nano-Solar Powered Station (Lightweight Nanostructured Light Energy Panels for enhanced power generation)
- Low Readiness & Applicability
- High Readiness & Applicability

NanoMalaysia IoNT Program 1

NanoBattery
Nano-Ultracap
Power
Monitoring
Management
NanoSensor
Signalling
System
Nano-Enhanced
Electronics
Nano
Anti-microbial
Technology
Nano-silver
Coating
Nano-Electronics
Mechanical
System
Integration
Interconnectivity
Data
Management
Big
Data
Analytics
IoT
Nano-Solar
Power
Station
Lightweight
Nanostructured
Light
Energy
Panels
Enhanced
Power
Generation
NanoMalaysia IoNT Program: Swiftlet Farming

**Nanostructured Energy Storage**
(Nano Battery/Ultracap & power monitoring and management system)

**Internal Maintenance**
(Antimicrobial and nano-coating, technology)

**Internal Control Network**
(Indoor environmental monitoring through nano-sensor system and close-loop control system)

**Big Data Analytics**
(Interconnectivity for remote data access and management. Performance enhancement through nanoelectronics)

**Nano-Solar Powered System**
(Lightweight Nanostructured Light Energy Panels for enhanced power generation)

**Wireless Network**
(System integration application with nano-enhanced electronics to monitor and control the swiftlet habitat)

**Internet of Things (IoT)** solutions

**Nanotechnology**

**Energy & Environment**

**Engineering**

Readiness & Applicability

Low

High

Exterior
(Nano-coating for exterior protection; outdoor environmental monitoring through nano-sensor system & RFID tagging for traceability)
NanoMalaysia’s Commercialization Programs

1. iNanovation
   - Facilitation of investment in Nanotechnology
   - Nanotechnology landscaping and Business opportunities
   - Strategy planning & consulting in commercialization of Nanotechnology R&D
   - Development of human capitals in Nanotechnology

   - Nanofluid
   - Plastic additives
   - Conductive ink
   - Li-ion battery/ultra-capacitors
   - Rubber additives

Nanotechnology Product and Process Verification and Certification supporting iNanovation and NGAP 2020
Commercialization Program 1: iNanovation

- **Multiple-helix facilitation scheme** for nanotechnology ventures
- **Interfacing with pre-existing facilities and programs throughout** the innovation value chain
- **Industry-driven incremental and revolutionary nanotechnology processes and products**

**High value Job Creation**

**Research & Academic Institutes (Collaborations)**
- Project entry
  - iPush
  - iPull
  - disruptive technologies (IPs, PoCs)

**Market share & GNI increase**
- • dividend
  - • royalties
  - • licensing

**Industry**
- **Push to market**
- **Market Pull**

**Jumpstart sectors:**

- Industry
- Manufacturing
- Revenue
- Project entry
- Project entry
- Project entry
- Project entry
- Minority holding
- Majority holding

- Multiple-helix facilitation scheme for nanotechnology ventures
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- Industry-driven incremental and revolutionary nanotechnology processes and products
Commercialization Program 2: NGAP2020 Project Execution

- **Focus on downstream applications** when innovating with Graphene
- **Priority on five applications** areas; Based on technical feasibility, economic viability, time to adoption, relevance and impact to Malaysia (2020 timeframe)
- **Comprehensive delivery framework** in facilitating and executing projects

**Awareness building & facilitating “projects”**

**1.** Access to R&D funding and prototyping
   - Facilitate “minority” funding for R&D and required prototyping facilities

**2.** Information on Graphene supply
   - Facilitate connection to potential source of Graphene

**3.** Access to technical experts
   - Manage & connect companies to expert networks

**4.** Access to IP advice
   - Facilitate introduction to IP advisory services for patent application or protection

**5.** Scale-up support

**6.** Co-ordination and monitoring

- Li-ion battery/ultra-capacitors
- Conductive ink
- Plastics
- Rubber additives
- Nanofluid