Nanotechnology and neuromorphic engineering

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Connecting People

Nokia is the world leader in mobility, driving the transformation and growth of the converging Internet and communications industries.

Nokia makes a wide range of mobile devices and provides people with experiences in music, navigation, video, television, imaging, games and business mobility through these devices.

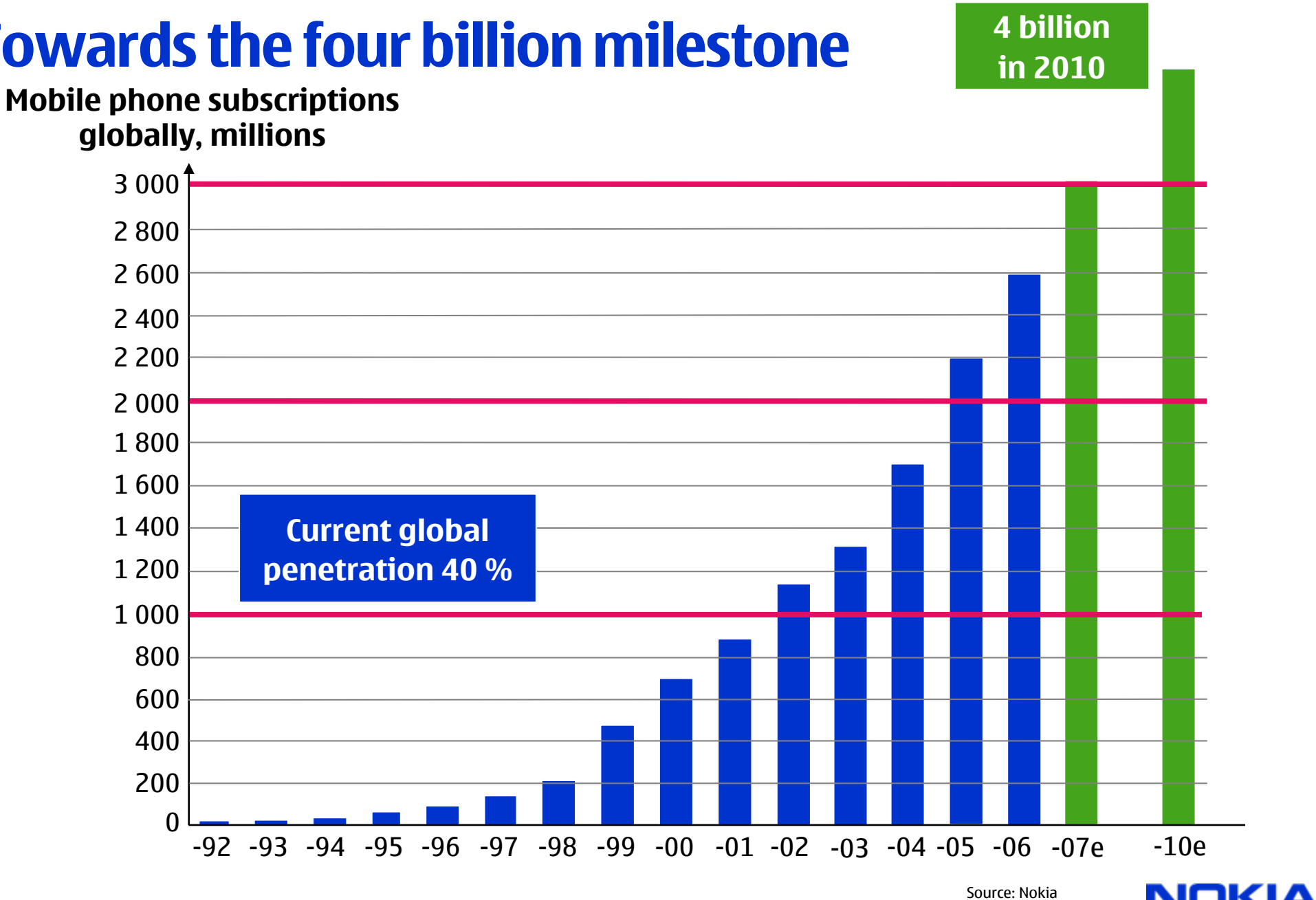
Nokia also provides equipment, solutions and services for communications networks.

Our history

1865 – 2006

From paper to mobile communications – through renewal and innovative use of technology

Towards the four billion milestone



Source: Nokia

Nokia brand

- Nokia is the world's 6th most valuable brand
- Emphasis on very human technology
- Nokia markets its devices in four categories: Live, Connect, Achieve and Explore
- Nokia Flagship stores: six opened by end 2006, more to come in 2007…

Nokia R&D

- R&D by Technology Platforms, Nokia business groups, Nokia Research Center and other research units

- 21 453 people in R&D at end of 2006 (approx. 31% of Nokia workforce)

- 2006 highlights:
  - New radio technology: Wibree
  - Nokia Research Centers in collaboration with MIT and Stanford University
  - S60 on Symbian OS chosen by operators Vodafone and Orange

Nokia Research Center

vision

Become the global leader of

open innovation

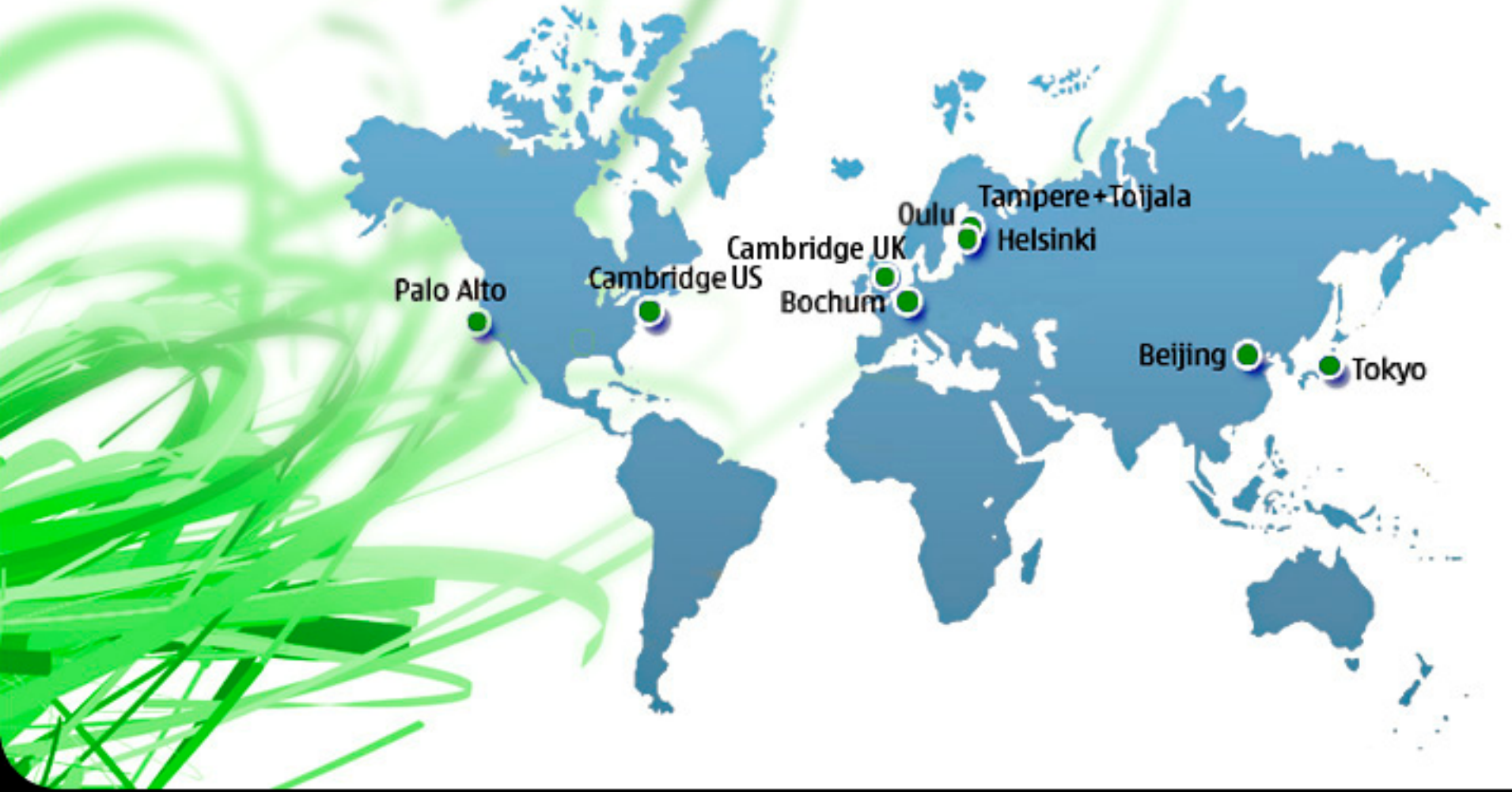
for human mobility systems of the

fused physical and digital world,

giving birth to the growth of

businesses for Nokia.

Nokia Research Center worldwide – strategically located



http://research.nokia.com

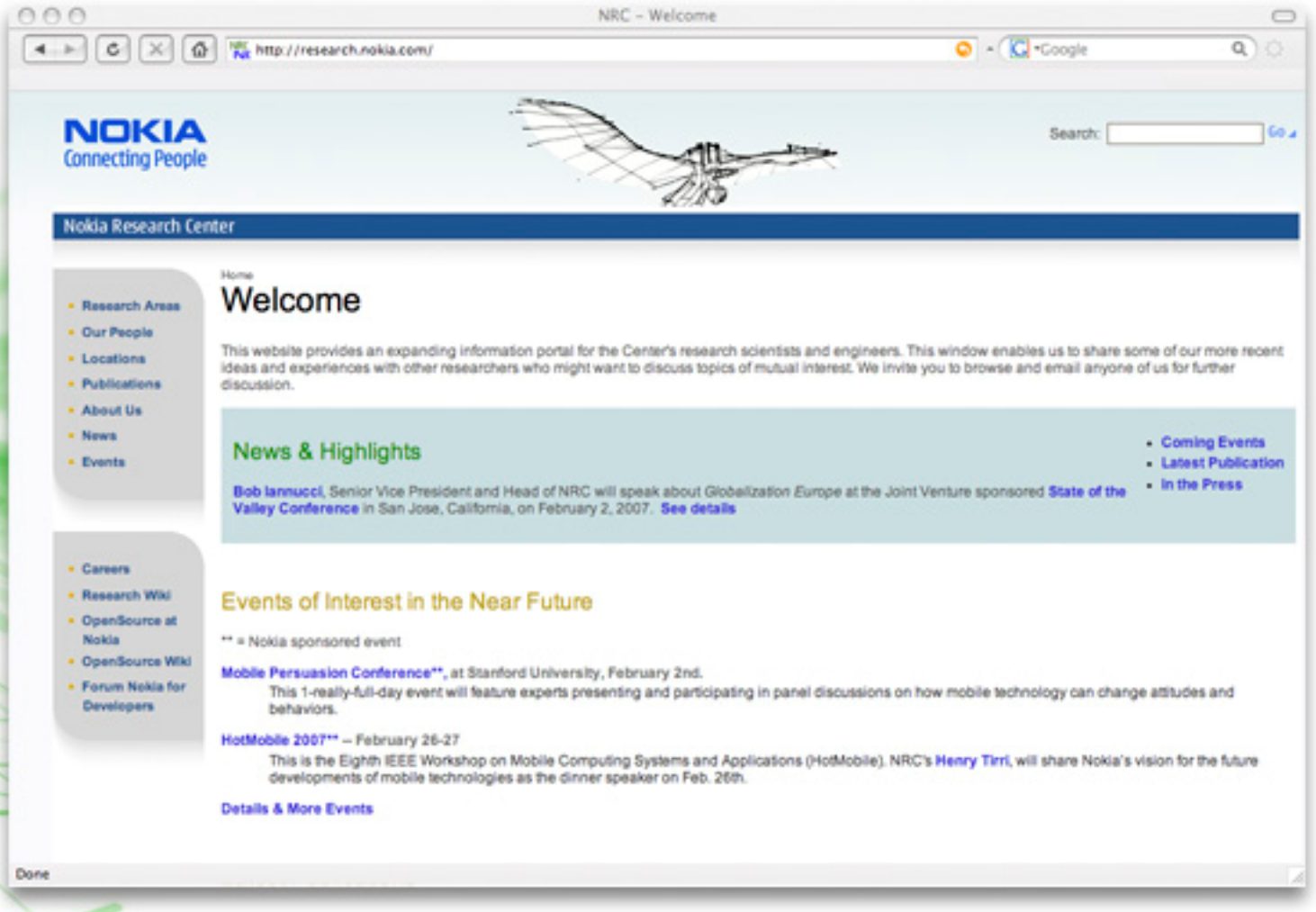
Research Areas

Blue Sky

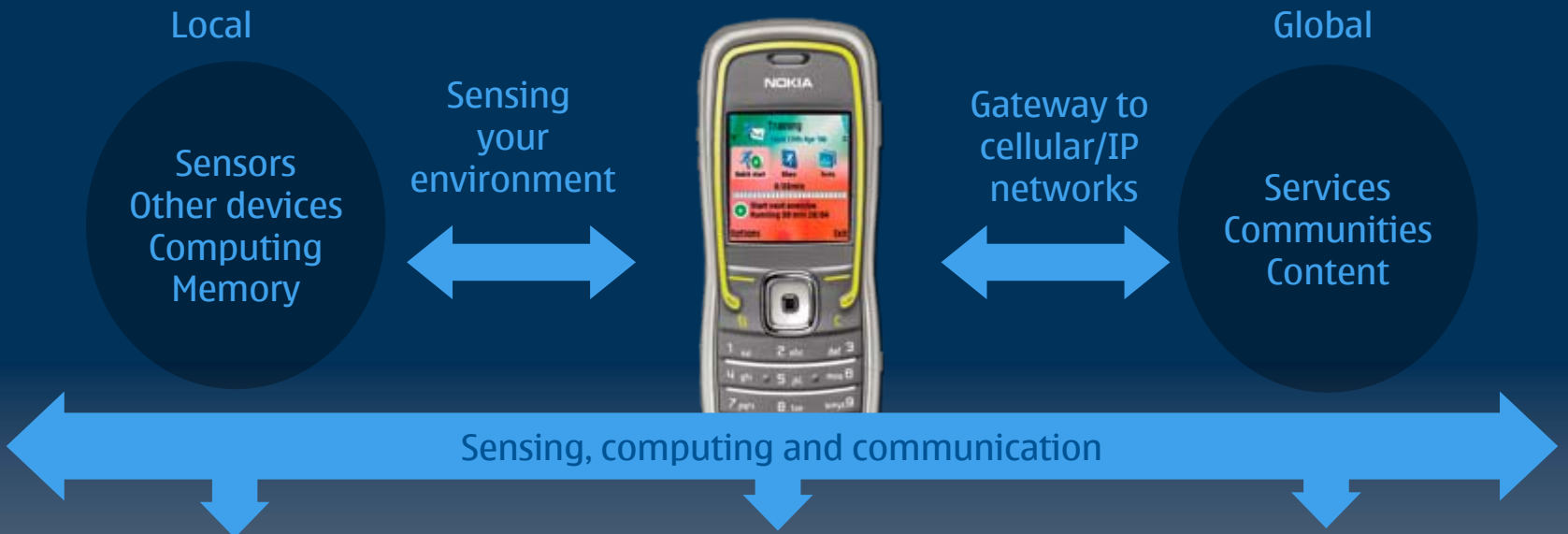
Our People

Locations

Open Source at Nokia



Future ubiquitous intelligence requires novel solutions



Physical objects in future intelligent environments

Future “wearable” personal trusted devices

Physical and digital worlds fuse

Towards solutions for future mobile and ambient intelligence devices

Ambient Intelligence

Mobile Gate way – Sensing, computing and communications

Future Mobile Applications

Micro and Nano Systems Architectures

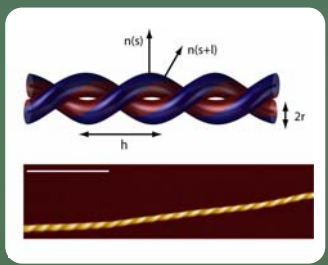
How to apply

Energy | Radios | Computing | Sensing | Mechanical structures

Innovative fabrication methods and manufacturing Solutions

Innovative materials

Nano Technology



Courtesy of the University of Cambridge, Nanoscience Centre

What is nanotechnology?

- Nanotechnology is a field of science and technology of controlling matter on a scale between 1-100 nanometers.
- It is a highly multidisciplinary field, bringing together many fields, including electrical and mechanical engineering, physics, chemistry, and biosciences. Nanotechnology will radically affect all these disciplines and their application areas.
- Economic impact is foreseen to be comparable to information technology and telecom industries.

Computing: more speed, less energy

- Moore's law in danger of not applying after 2015?
- New materials
- Nanoelements included into traditional circuits
  - FPNI by HP, interconnects by nanotech
  - CNT components, IBM
- Totally new type of approaches

Physical realization of computing devices

- Charge based devices
- Magnetic interactions (e.g. spintronics)
- Flux of photons
- Plasmons
- Chemical interactions (slow per computation, massively parallel)
- Mechanical devices (origin of computers)
- Biological devices

Characteristics of nanotechnology

- Devices more stochastic
- Quantum effects the rule, not the exception
- More faulty devices, how to survive?
  - Reconfiguration
  - Redundant elements
  - Bio-inspired parallel computation

Cellular nonlinear/neural networks

- Array of identical dynamical systems, cells
- Local interactions – manufacturability
- Proposals and simulations on implementation with
  - QCAs
  - SETs
  - RTDs

Likharev et al.

- CMOL:
  - CMOS with cell somas
  - Synapses and connections with nano crossbar

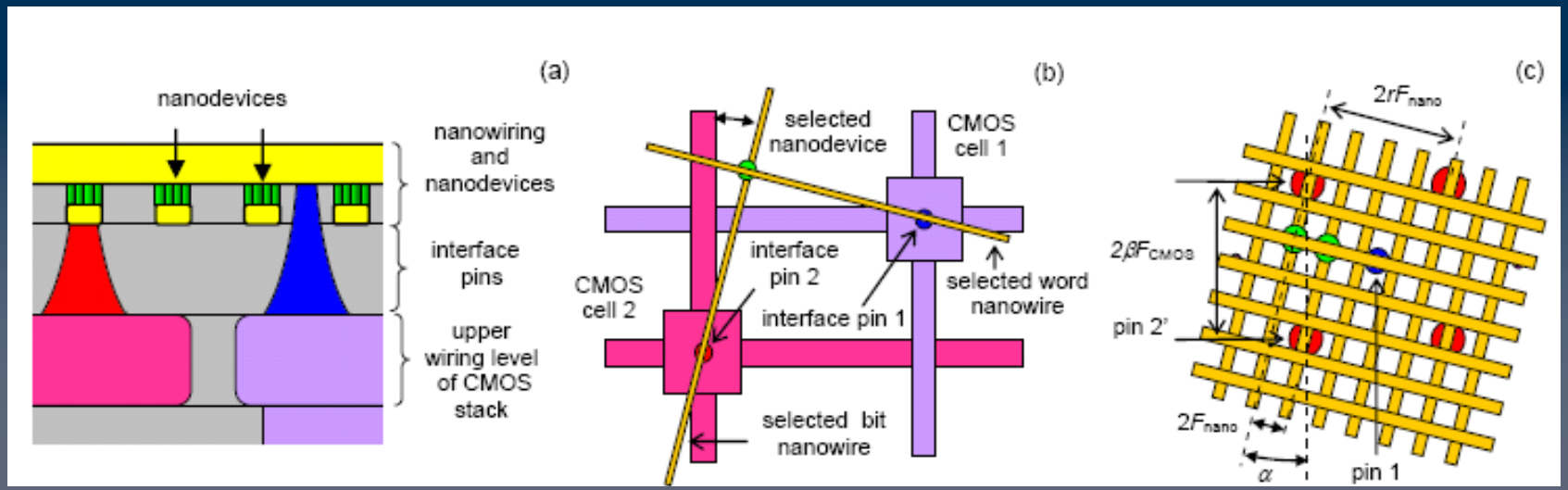


Figure 1 Low level structure of a generic CMOL circuit (a) side view (b) and (c) how to address individual nanodevice and the CMOS wiring.

Questions to discuss

- What are the limits to neuromorphic engineering with VLSI?
- What are the greatest results of neuromorphic engineering so far?
- What is there to come?

- What and when can nanotech provide?
- Will nanotech change the game?
- What can we achieve before nanotech?

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