

# **International Workshop on *Intelligent Multi-core Systems***

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University of Essex

# Robotics and Embedded Systems Group @Essex

- **Many academics and researchers**
- **My Research Areas**
  - **Advanced embedded systems for several applications, e.g. automotive, robotics, image processing and IoT**
  - **Computer vision and embedded AI for real world problems**
  - **HPC Data centers and Cloud Computing**
  - **Technologies to improve security, reliability, power and performance**
    - **DSE, AI-based, Biology- and Market-inspired, etc.**

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# Outline

- **Overview of multi-core systems**
- **Computation and communication issues in multi-core systems**
- **The need for intelligence**
- **Intelligent adaptations and challenges**
- **The search for right level of intelligence**
- **State-of-the-art intelligence**
- **Envisioned future intelligence**

**What is your name and designation? (You can answer as: Amit-Associate Professor, Alex-Embedded Engineer, Adam-BTech Student, etc.)**

**What are your interests? (You can answer as:  
Embedded Systems, C Programming, etc.)**

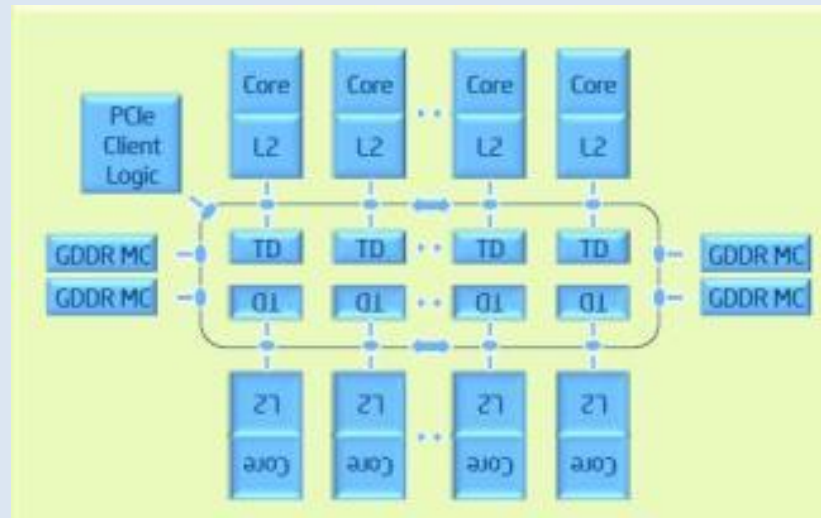
# Overview of multi-core systems

# Multi-core System

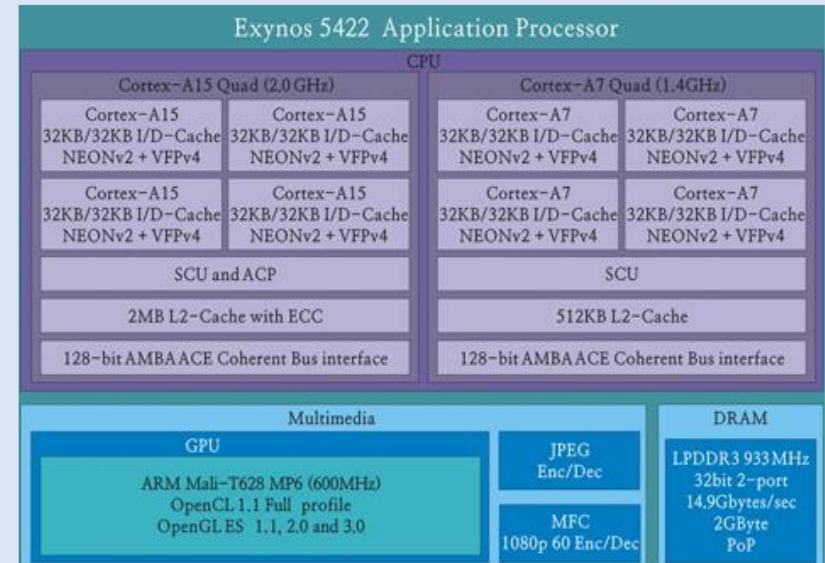
A multi-core system is realised on a single physical processor that contains the logic of two or more processors, which are packed together in a single integrated circuit (chip).

# Multi-core Chips

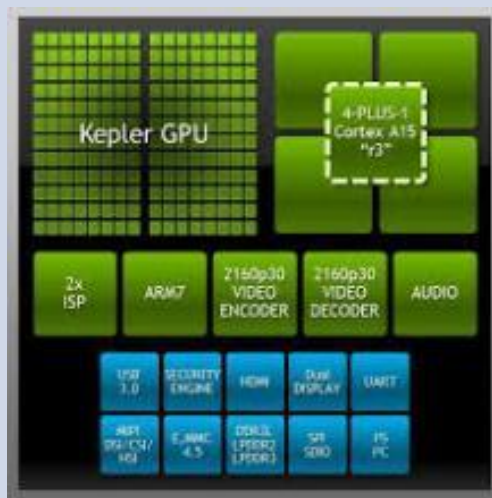
Intel Xeon Phi - **Homogeneous 61 Cores**



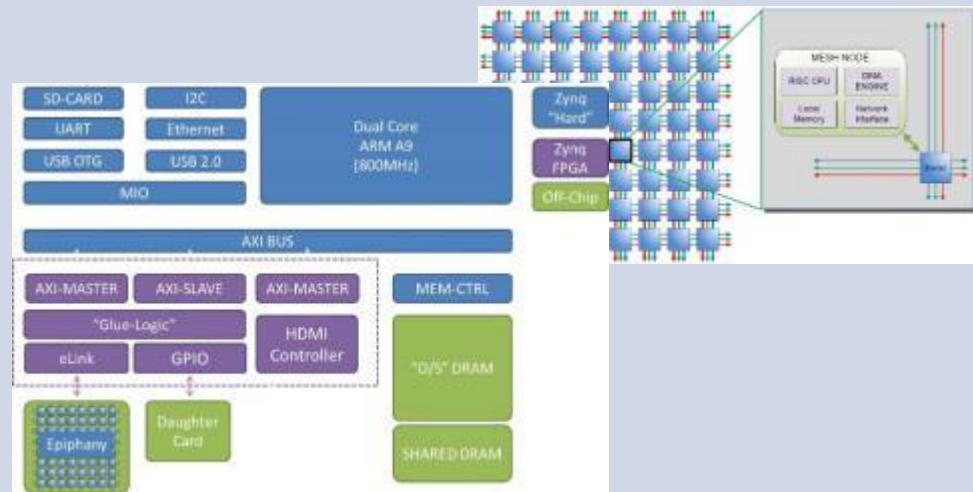
ODROID XU3 – **8 core big.LITTLE CPU + 6 cores GPU**



Nvidia Jetson TK1 - **Quad core CPU + 192 cores GPU**



Parallella - **Dual core CPU + FPGA + 16 cores NoC**

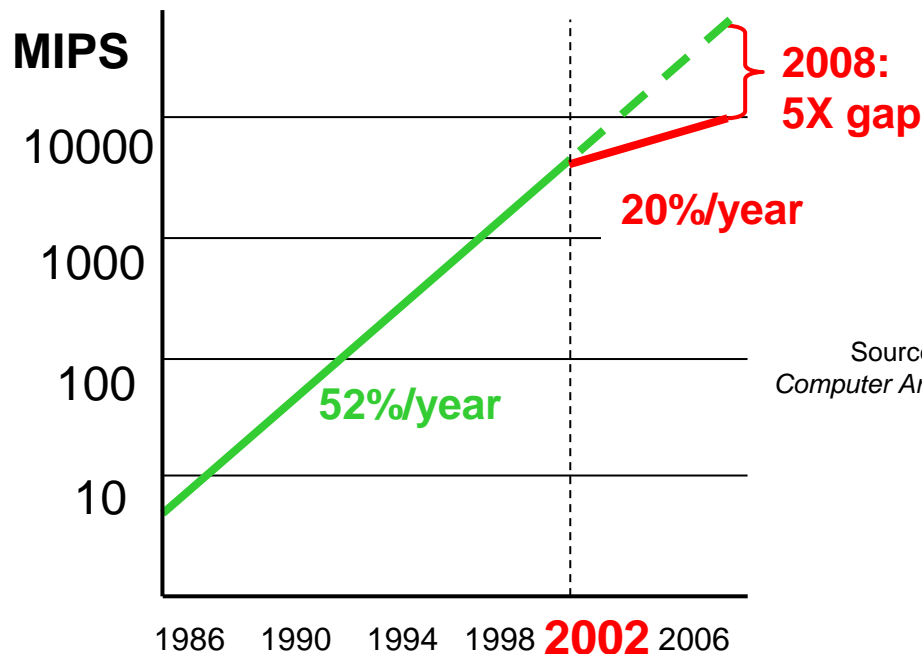




# Why multi-core system came to real-world?

# Multi-core Systems Revolution

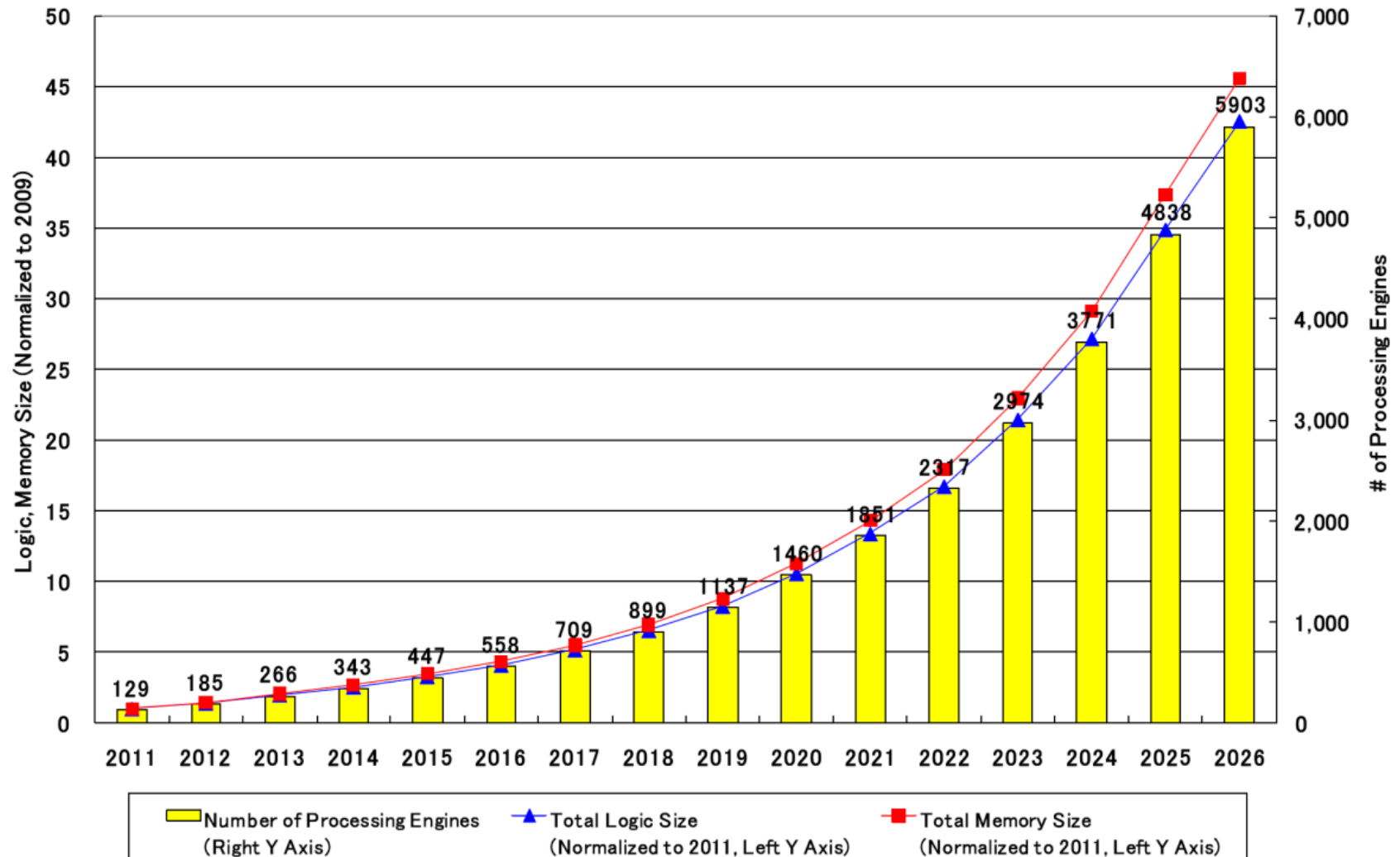
- **Single Core Performance:**
  - **Steady until 2002**
  - **Performance has fallen off Moore's Law**
    - **Maximum operational frequency has hit the roof**



Source: Hennessy & Patterson,  
*Computer Architecture: A Quantitative  
Approach*, 4th ed.

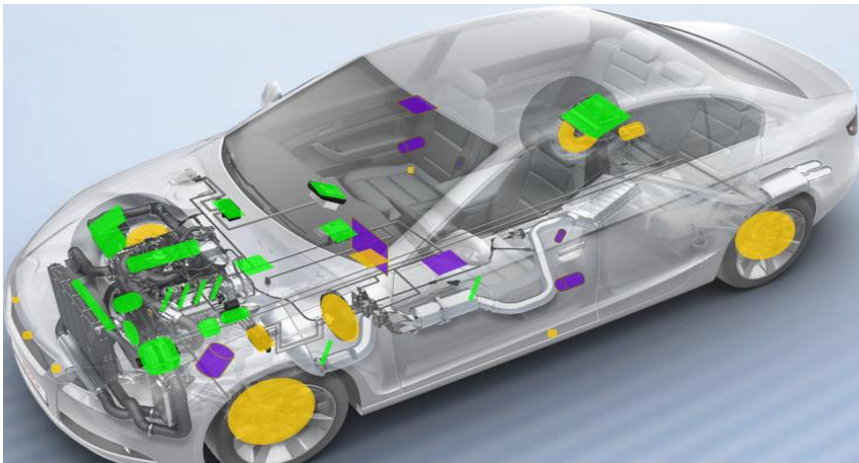
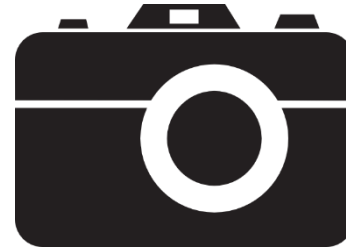
- **Parallel processing is the only choice**

# Evolution in number of cores



Source: ITRS

# Examples of Multi-core Systems

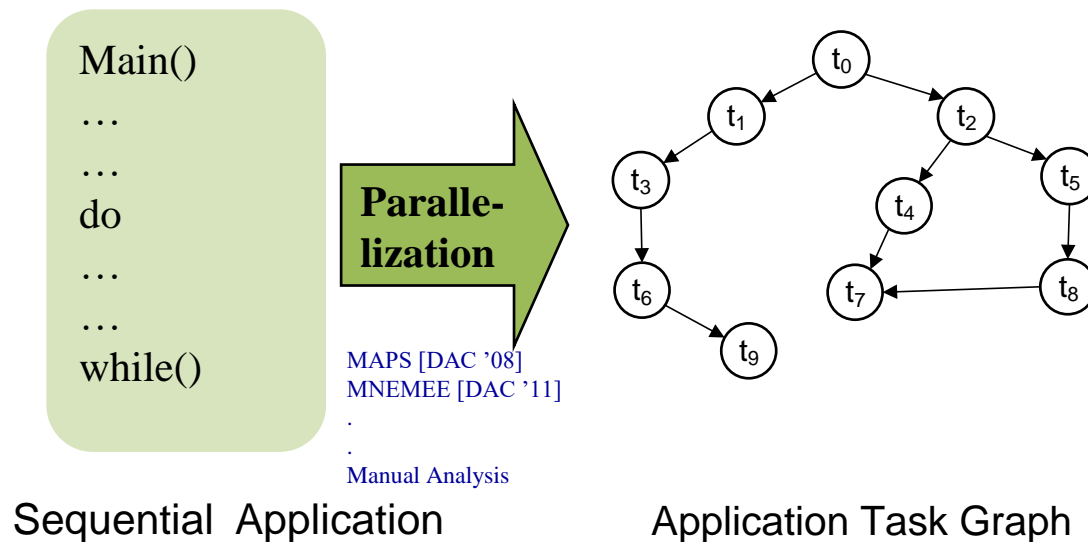


# Other examples of multi-core systems?

# **Computation and communication issues in multi-core systems**

# **Why computation and communication issues appear in any system?**

# Applications Execution on Multi-core Systems

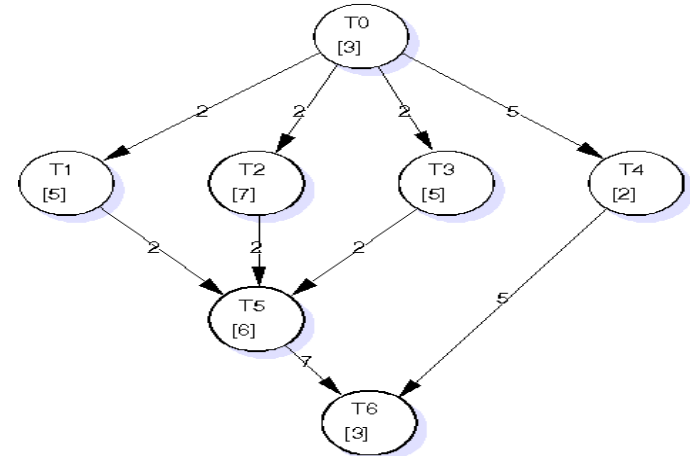




# Applications Execution on Multi-core Systems

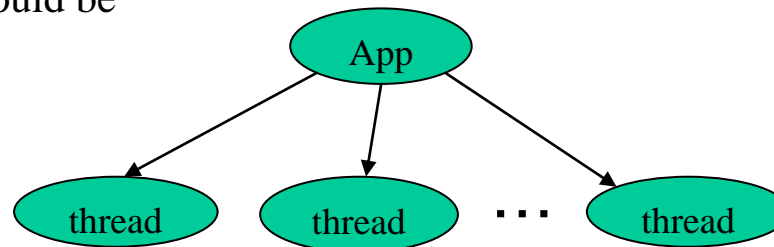
- Applications Representation

- Task parallelism

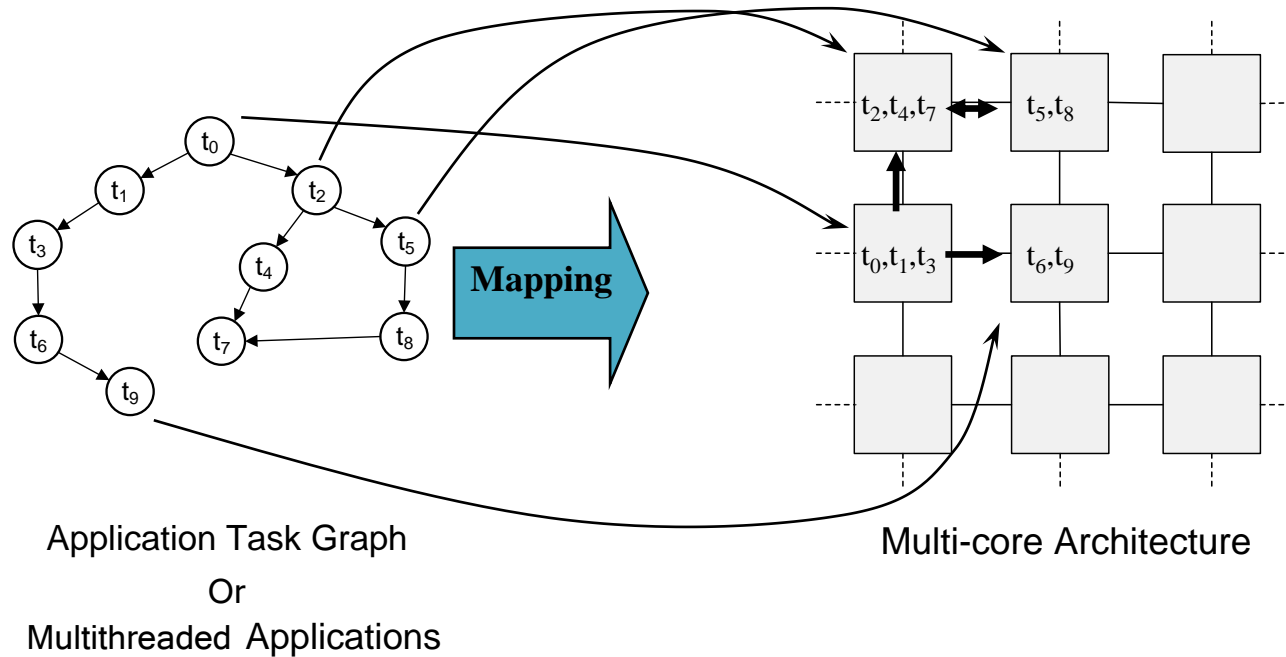


- Thread parallelism

- A task/application could be multi-threaded

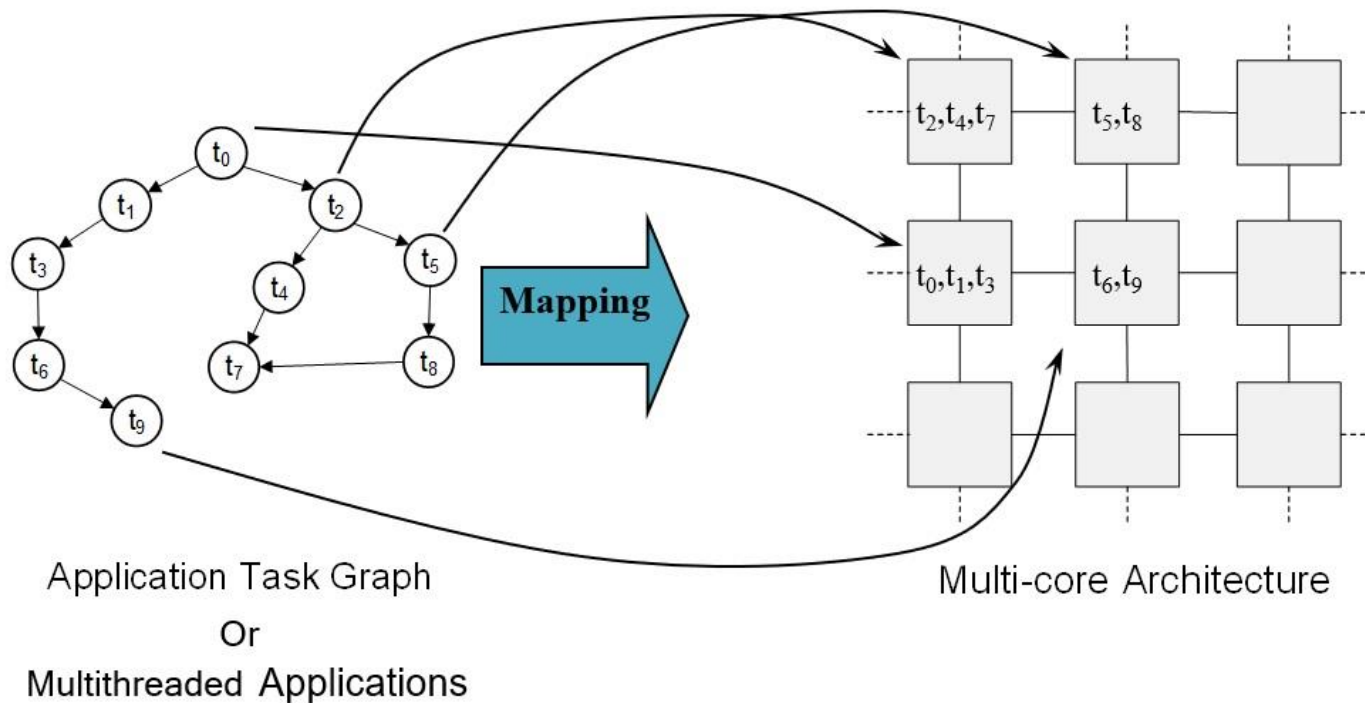


# Applications Execution on Multi-core Systems



- Mapping process defines assignment and ordering of the tasks and their communications onto the platform resources in view of some optimization criteria such as energy consumption and compute performance.
- Assignment and ordering of the tasks for computation issues
- Assignment and ordering of the tasks's communications for computation issues

# Solving Computation Issues



- Homogeneously distribute loads of tasks on the cores
- Bring heterogeneous cores
- Apply dynamic voltage and frequency scaling (DVFS)

# **Other consideration(s) to solve computational issues?**

# To achieve maximum performance for an application, which issue to solve?

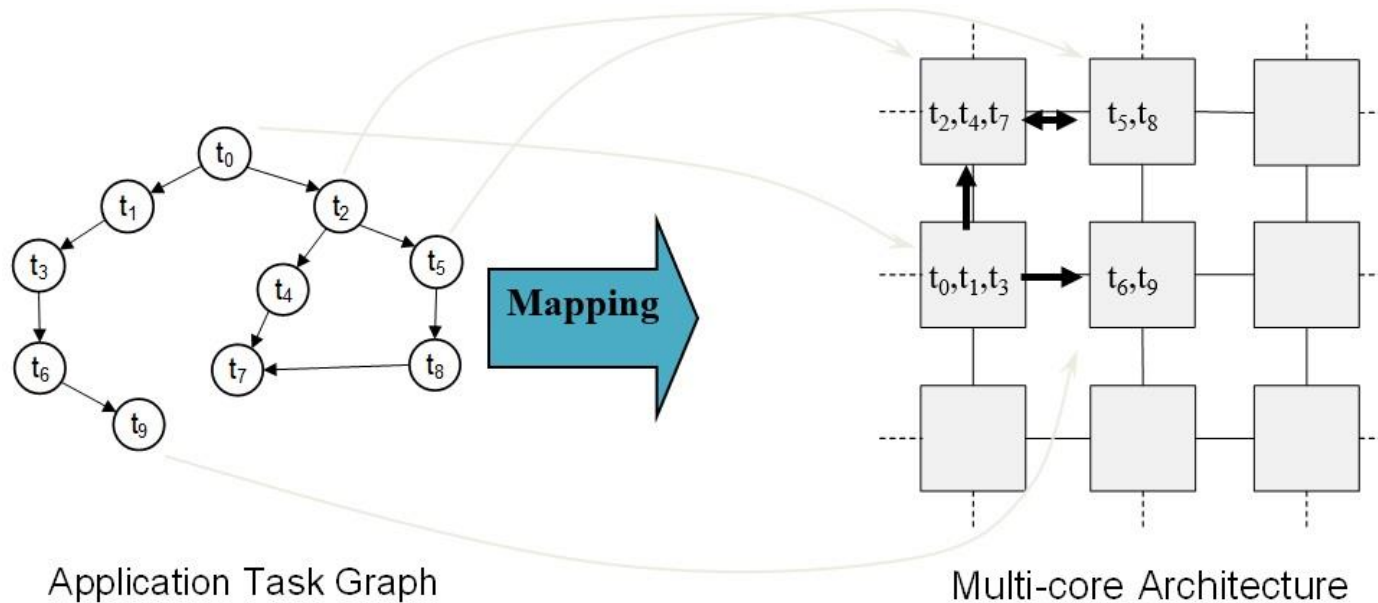
Computation issue **A**

Communication issue **B**

Both computation and communication issues **C**

None of the above **D**

# Solving Communication Issues



Application Task Graph  
Or  
Multithreaded Applications

Multi-core Architecture

- Homogeneously distribute communication loads on the links
- Bring heterogeneous links
- Apply dynamic voltage and frequency scaling (DVFS)

# **Other consideration(s) to solve communication issues?**

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📱 Text **AMITSINGH510** to **22333** once to join

# To achieve minimum energy consumption, which issue to solve?

Computation issue

Communication issue

Both computation and  
communication issues

None of the above



# Additional important metrics

- Reliability
- Security
- Cost
- QoE
- Accuracy
- ...

🌐 When poll is active, respond at **pollev.com/amitsingh510**

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**Can we say that each metric (e.g. security, cost, QoE) can be optimised by addressing computation and communication issues?**

Yes

No

# Summarising

- Overview of multi-core systems
- Computation and communication issues in multi-core systems
- Next-> The need for intelligence

# Further Questions?