

# GMetis - Xeon Phi

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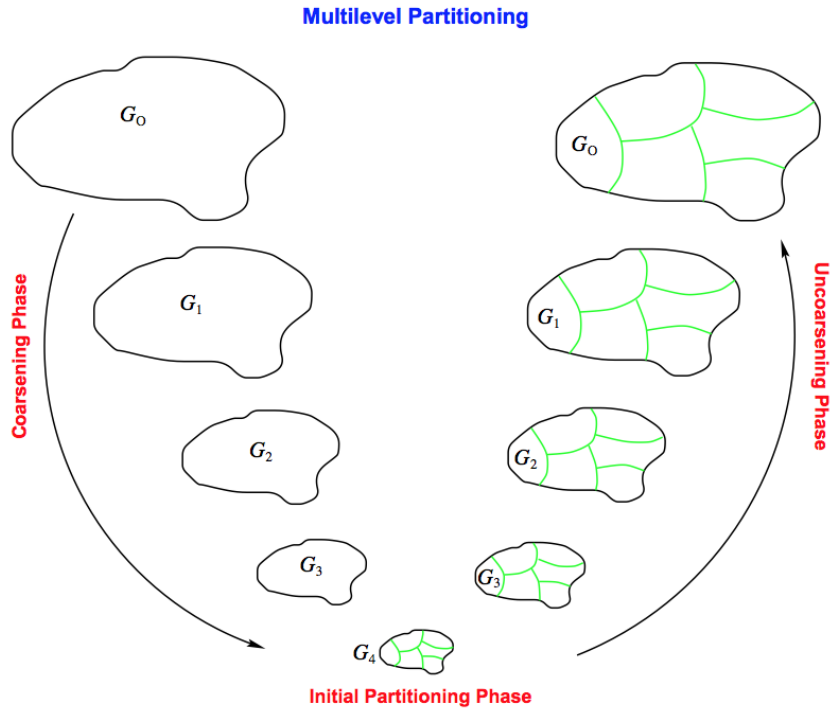
# Outline

- 1 Introduction
- 2 Algorithm Description
- 3 System characteristics
- 4 Conclusion

# Introduction

- GMetis is a graph partitioning application which uses the Galois framework
- Consists of three major phases
  - ▶ Coarsening
    - ★ Find matching nodes
    - ★ Create Coarse Edges
  - ▶ Initial Partitioning (Clustering)
  - ▶ Refinement

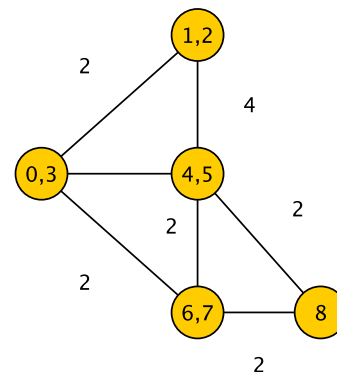
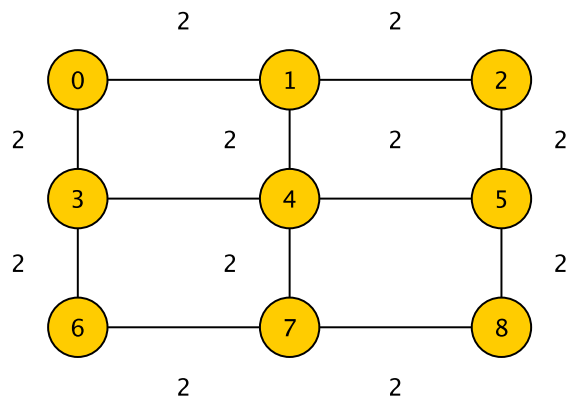
# Algorithm Description



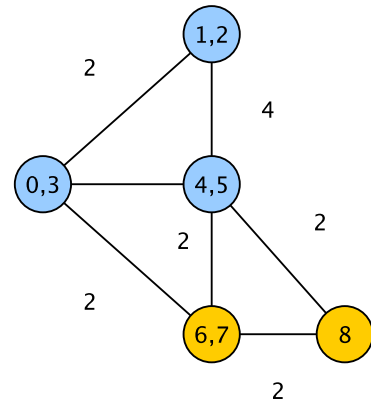
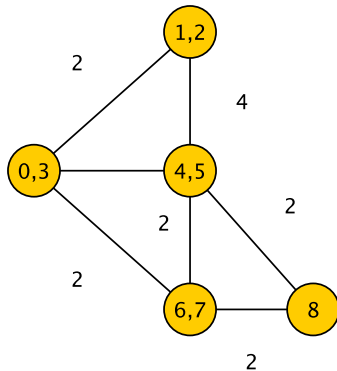
# Formal Description

- Given a graph  $G_0 = (V_0, E_0)$ :
  - ▶ Coarsening
    - ★  $G_0$  is transformed into a sequence of smaller graphs  $G_1, G_2, \dots, G_m$  such that  $|V_0| > |V_1| > |V_2| > \dots > |V_m|$
  - ▶ Partitioning
    - ★ A 2-way partition  $P_m$  of the graph  $G_m = (V_m, E_m)$  is computed that partitions  $V_m$  into two parts, each containing half the vertices of  $G_0$
  - ▶ Refinement
    - ★ The partition  $P_m$  of  $G_m$  is projected back to  $G_0$  by going through intermediate partitions  $P_{m-1}, P_{m-2}, \dots, P_1, P_0$

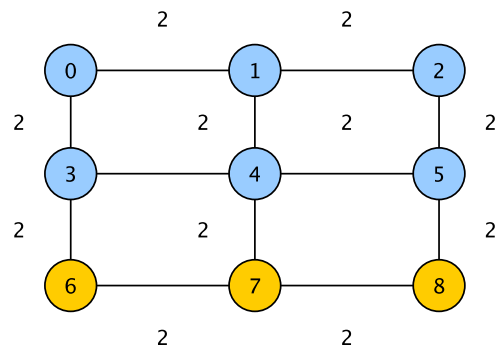
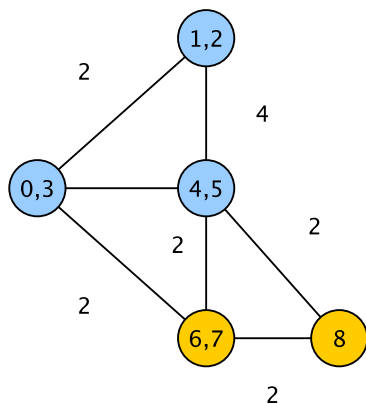
# Coarsening



# Partitioning



# Refinement





# Stampede Host

Manufacturer	Intel
Model	Xeon E5-2680
$\mu$ Arch	Sandy Bridge
Clock freq	2.70 GHz
#CPUs (sockets)	2
#Cores/CPU	8
#Thread/Core	1
L1 cache size/core	32 KB
L2 cache size/core	256 KB
L3 shared cache size/CPU	20 MB
Main Memory/CPU	16 GB
Vector width	256 bits (AVX)

**Table 1 :** Intel Xeon E5-2680

# Stampede Co-processor - Xeon Phi

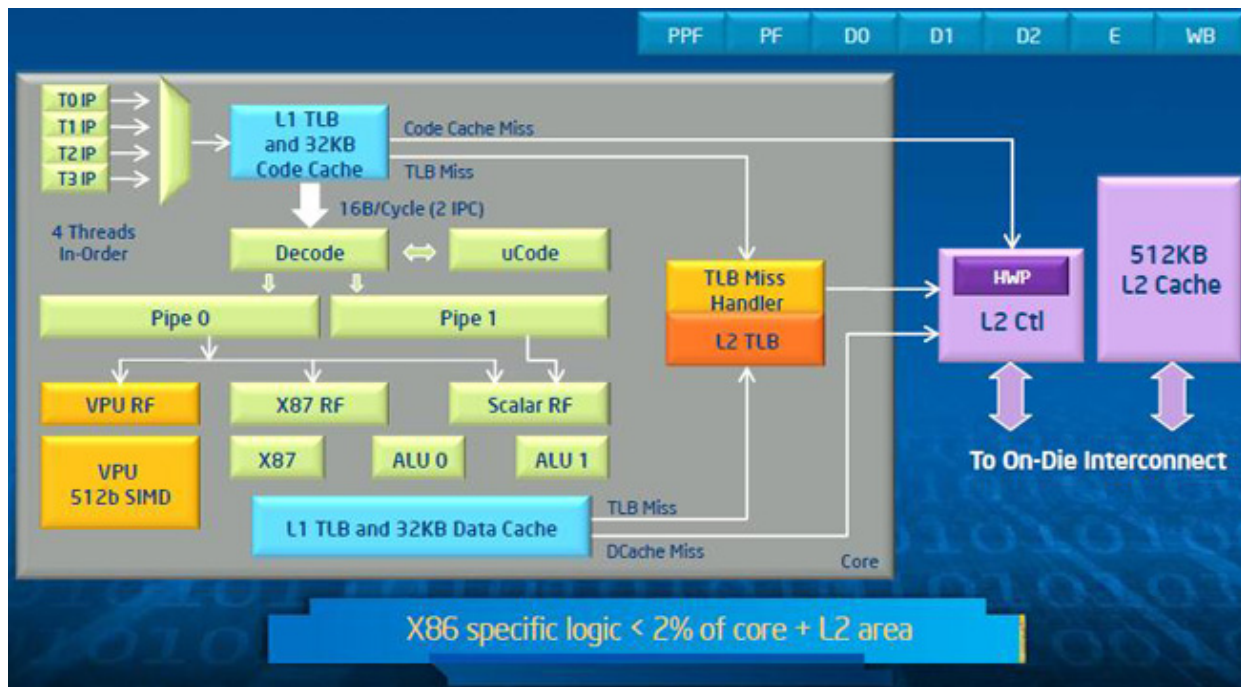
Manufacturer	Intel
Model	Xeon Phi SE10P
$\mu$ Arch	Many Integrated Cores - MIC
Clock freq	1.1 GHz
#CPUs (sockets)	1
#Cores/CPU	61
#Thread/Core	4
L1 cache size/core	32KB
L2 cache size/core	512 KB
Main Memory/CPU	8 GB
Vector width	512 bits

**Table 2 :** Intel Xeon Phi

# Important characteristics

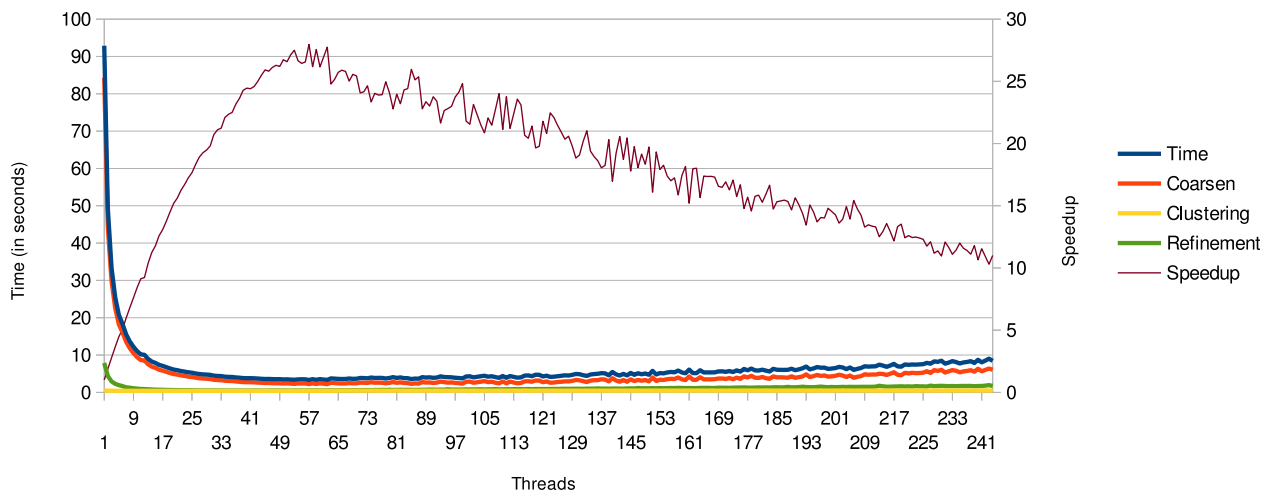
- Four hardware threads per core
- In-order dual issue pipeline
- Pipeline does not issue instructions from the same hardware context for two consecutive clock cycles
- Maximum issue rate only attainable with at least 2 threads per core

# Xeon Phi Coprocessor Core<sup>1</sup>



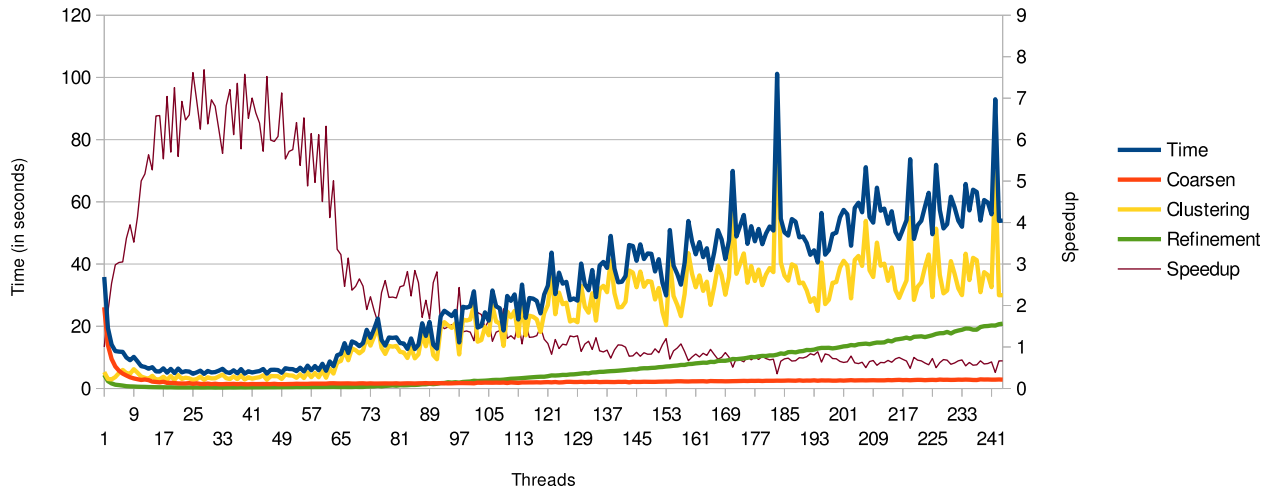
<sup>1</sup><http://software.intel.com/en-us/articles/intel-xeon-phi-coprocessor-codename-knights-corner>

GMetis - 128 partitions



<sup>2</sup>USA-road-d.W.gr with 6262104 nodes and 15248146 edges

mt-metis - 128 partitions

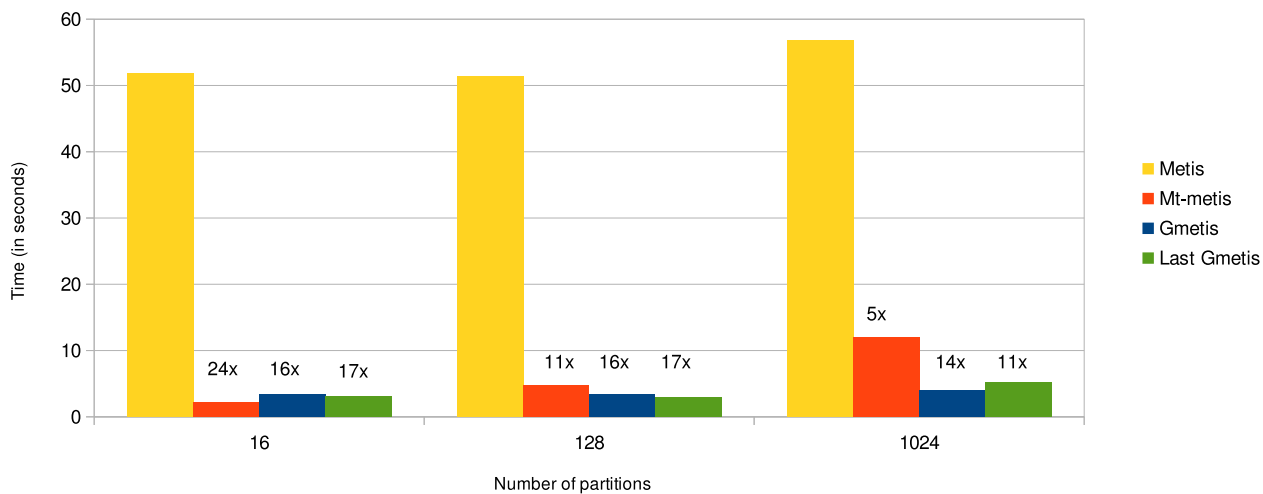


# Enhancements

- Package Mapping (HW Topology)
  - ▶ Default Mapping
  - ▶ Load Balance
  - ▶ Dense Package
- Use of Random Match and Heavy Weight Match
- WorkList schedulers
- Software prefetching

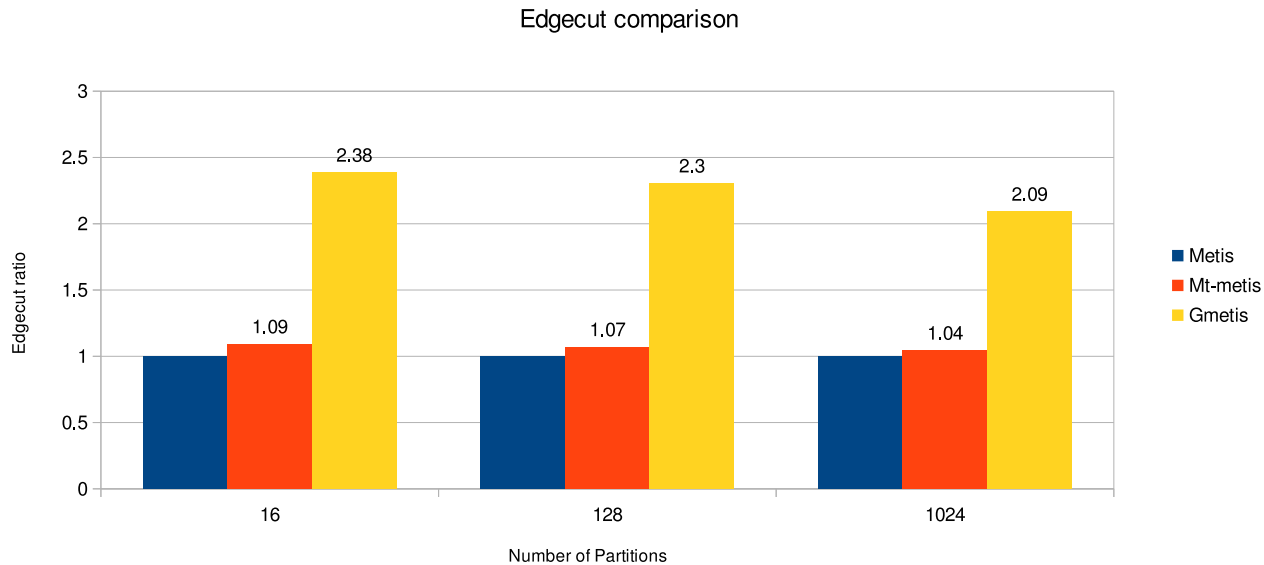
# Metis Comparison

Metis comparison - Xeon Phi





# Edgecut comparison



# Conclusion

- Metis and mt-metis have better edgecut;
- Metis and mt-metis have lower runtimes for a smaller number of partitions;
- GMetis is faster for a high number of partitions;
- Metis graph partitioning algorithm is not suitable to run on MIC as it does not use SIMD extensions;
- Lack of software/profilers made progress difficult;

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