CSE633 Parallel Algorithms, Fall 2010
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Parallel Implementation of Mining Highly Interacted Attribute Pairs

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Interaction Mining

- For two attribute variables X_1 and X_2 and a class variable Y, when relationship between X_1 and Y depends on X_2 , X_1 and X_2 are said to be *interact*.
- Interactions are outcomes that occur when all the variables are observed together
  - Interaction between two variables exists when the joint effect of both is different from that obtained by additively combining the individual effects.
- Different interactions: independence, synergy, redundancy.

Interaction Mining using Information Theory

- Let ω denote the set of all random variables :

$$\omega = \{ X_1 ; X_2 ;\ldots X_i ; \ldots ; X_N \}.$$

X_i : A random variable representing an attribute or class label

- Entropy

$$H(X_i) = -\sum_x p(X_i = x)\log_2(p(X_i = x))$$

- KWII : Amount of information present in a set of variables, which is not present in any subset of the variables.
  - For set of variables $S = \{ X_1; X_2;\ldots, X_\mathrm{K} \}$

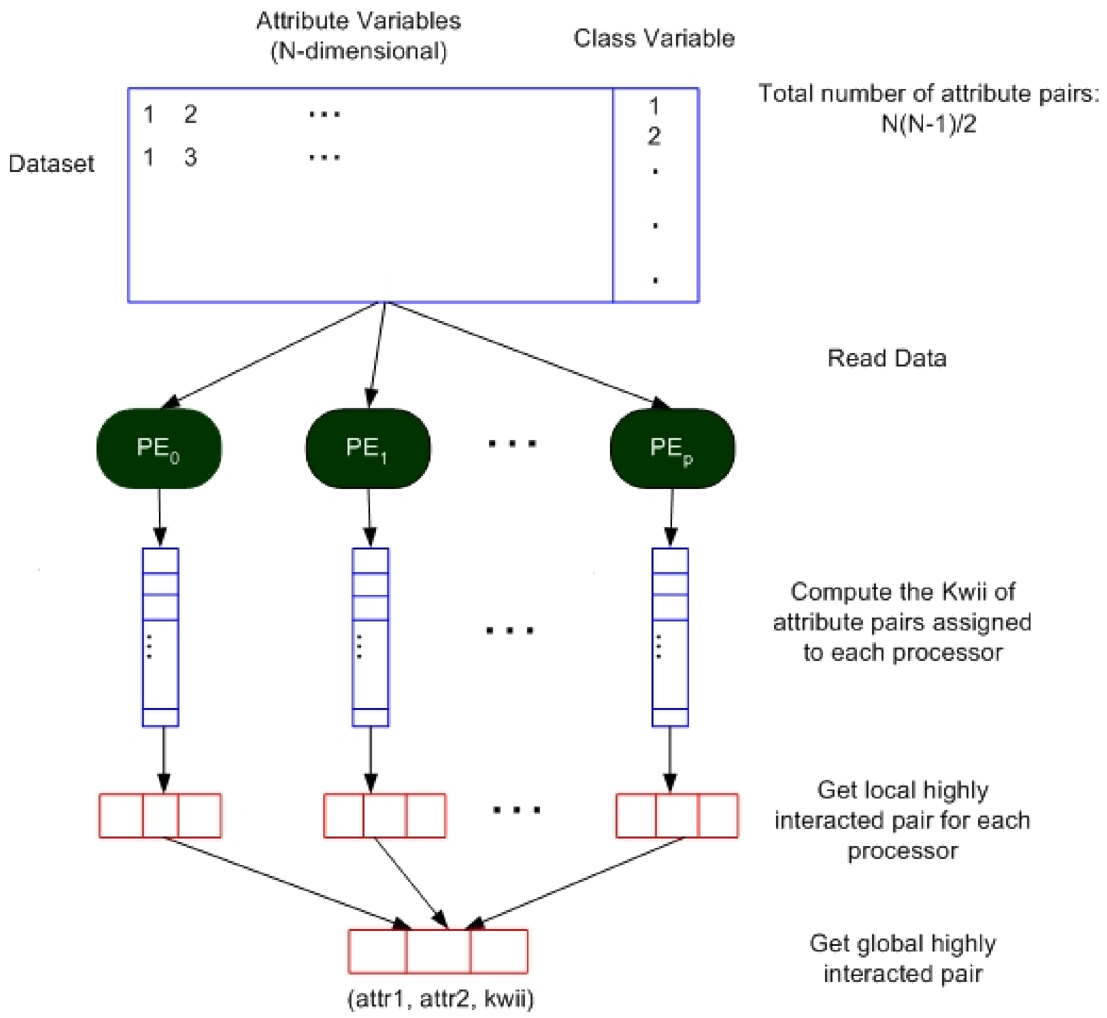
$$KWII(S) \equiv -\sum_{T \subseteq S} (-1)^{|S \setminus T|} H(T)$$

- e.g. KWII (A;B;C) = $-\underbrace{H(A) - H(B) - H(C)}_{} + \underbrace{H(AB) + H(AC) + H(BC)}_{}$
  $-\underbrace{H(ABC)}_{}$

Experiment Setting

- **Input:** Data set of n attribute variables and class variable, number of sample is m
- **Computation:** Compute the KWII values for all possible attribute pairs
  - for N attributes, # of attribute pairs will be n*(n-1)/2
- **Output:** Attribute pairs with highest KWII value, which is the most significant interacted pairs
- **Sequential running time**: O(n^2m)
  - Can be very time consuming when n is large
  - Turn to parallel solution!

Parallel Implementation



Attribute Variables (N-dimensional)

Class Variable

Total number of attribute pairs: N(N-1)/2

Read Data

Compute the Kwii of attribute pairs assigned to each processor

Get local highly interacted pair for each processor

Get global highly interacted pair

(attr1, attr2, kwii)

Part of Implementation Detail

- The computation of KWII for all attribute pairs is evenly distributed across all the processors

```
int pairs_per_node=(attr_num)*(attr_num-1)/(2*size) +1;
 ...... ......
for(int attr1=0;attr1<attr_num;attr1++)
{
    for(int attr2=attr1+1;attr2<attr_num;attr2++)
    {
          count_current=(2*attr_num-attr1)*attr1/2+attr2-attr1;
          //decide whether the KWII computation of current pair is assigned to this node or not
          if( count_current>= (pairs_per_node*rank +1)  &&  count_current<= (pairs_per_node*(rank +1)))
           {
                  printf("attr1 is: %d, attr2 is: %d, count_current is: %d, rank is: %d \n",attr1,attr2,count_current,rank);

                  kwii.kwii(D,sample_num,v);
                  ......


          }
    }
}
```

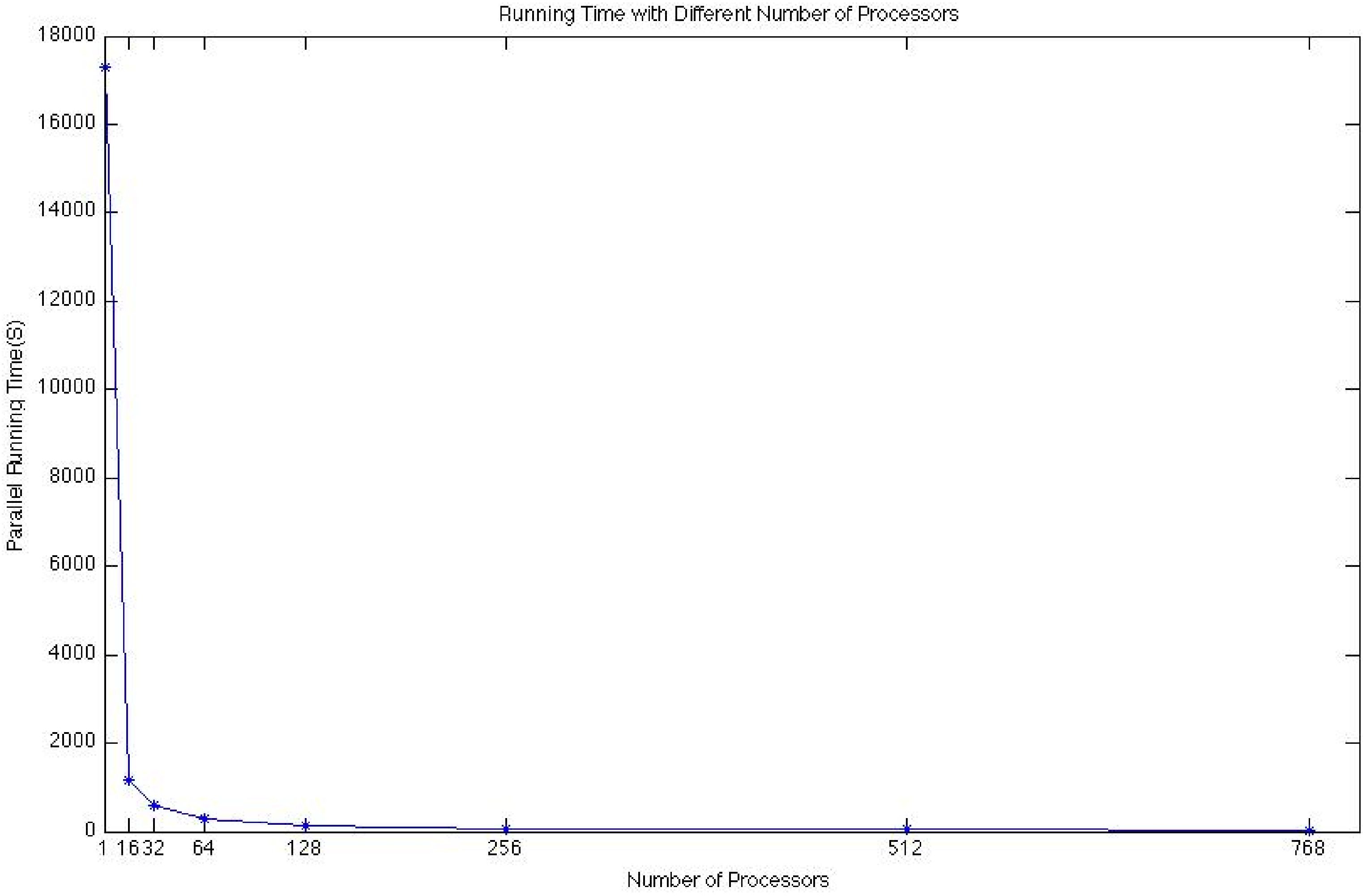
Part of Implementation Detail

- Each processor picks up the attribute pair with the local highest KWII values and send it to P_0
  - Define a derived data types Result using triplet of (int, int, double) to store the results of attribute pair and KWII values

```
MPI_Datatype myresult,old_types[2]={MPI_INT,MPI_DOUBLE};
MPI_Aint indices[2];
int blocklens[2]={2,1};
MPI_Address(&r,&indices[0]);
MPI_Address(&r.kwii,&indices[1]);
indices[1] -= indices[0];indices[0]=0;
MPI_Type_struct(2,blocklens,indices,old_types,&myresult);
MPI_Type_commit(&myresult);
………………
MPI_Type_free(&myresult);
```

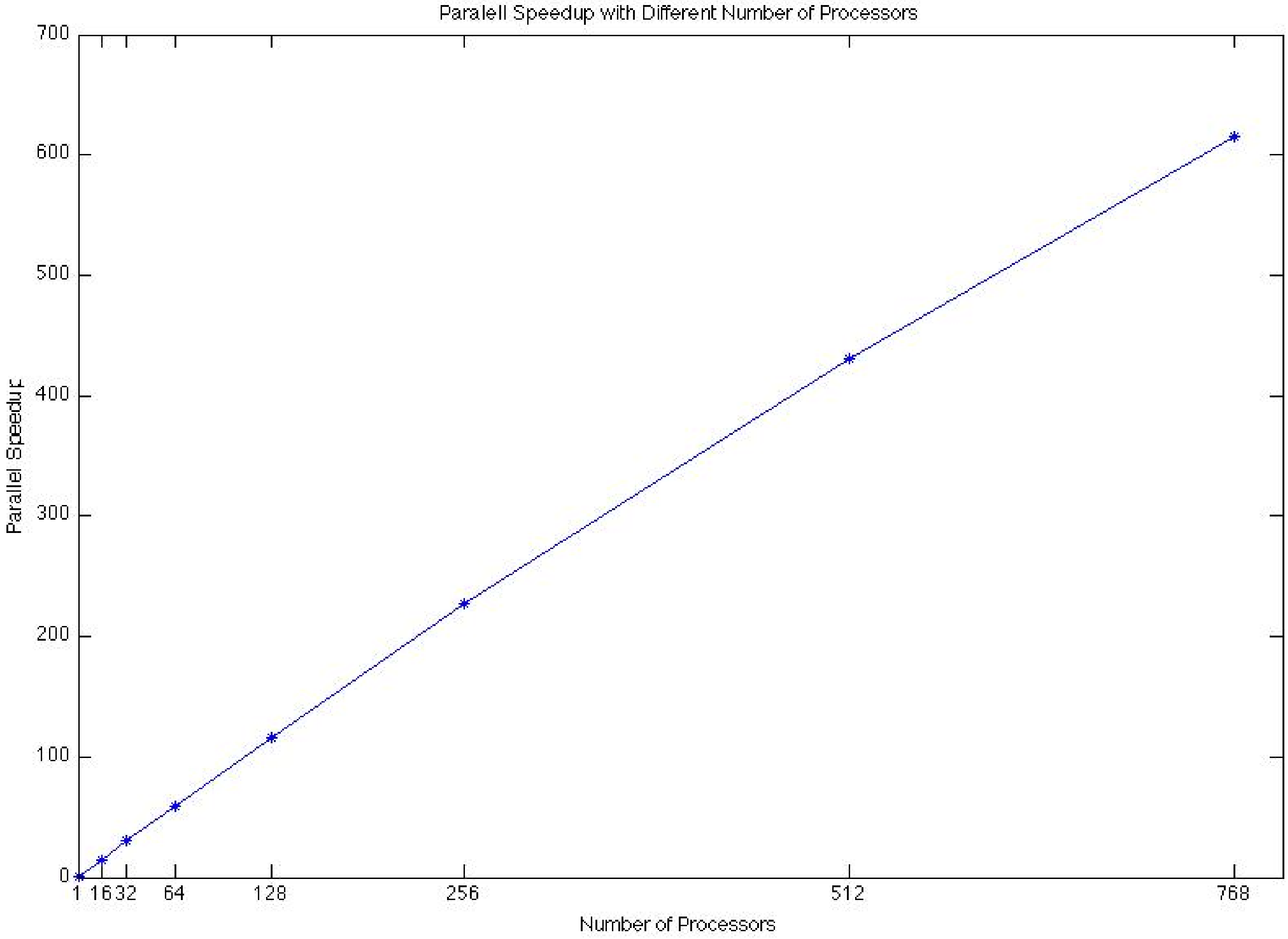
- P_0 receives the Result from all other processors and picks up the one with the highest KWII value as the global highly interacted attribute pair

Parallel Running Time



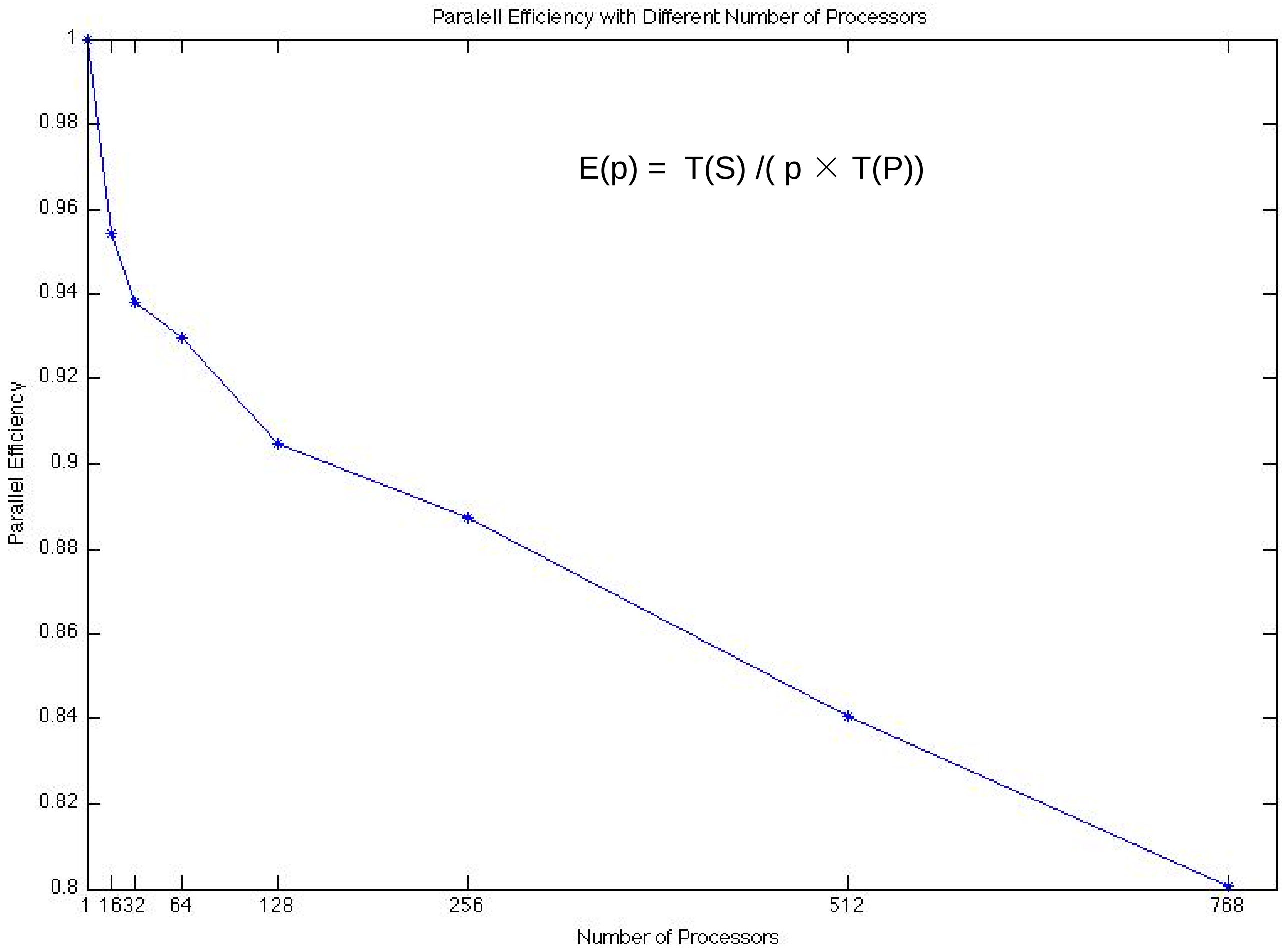
# of attributes = 5000, # of samples = 1000

Parallel Speedup



# of attributes = 5000, # of samples = 1000

Parallel Efficiency



$E(p) = T(S) /(p \times T(P))$

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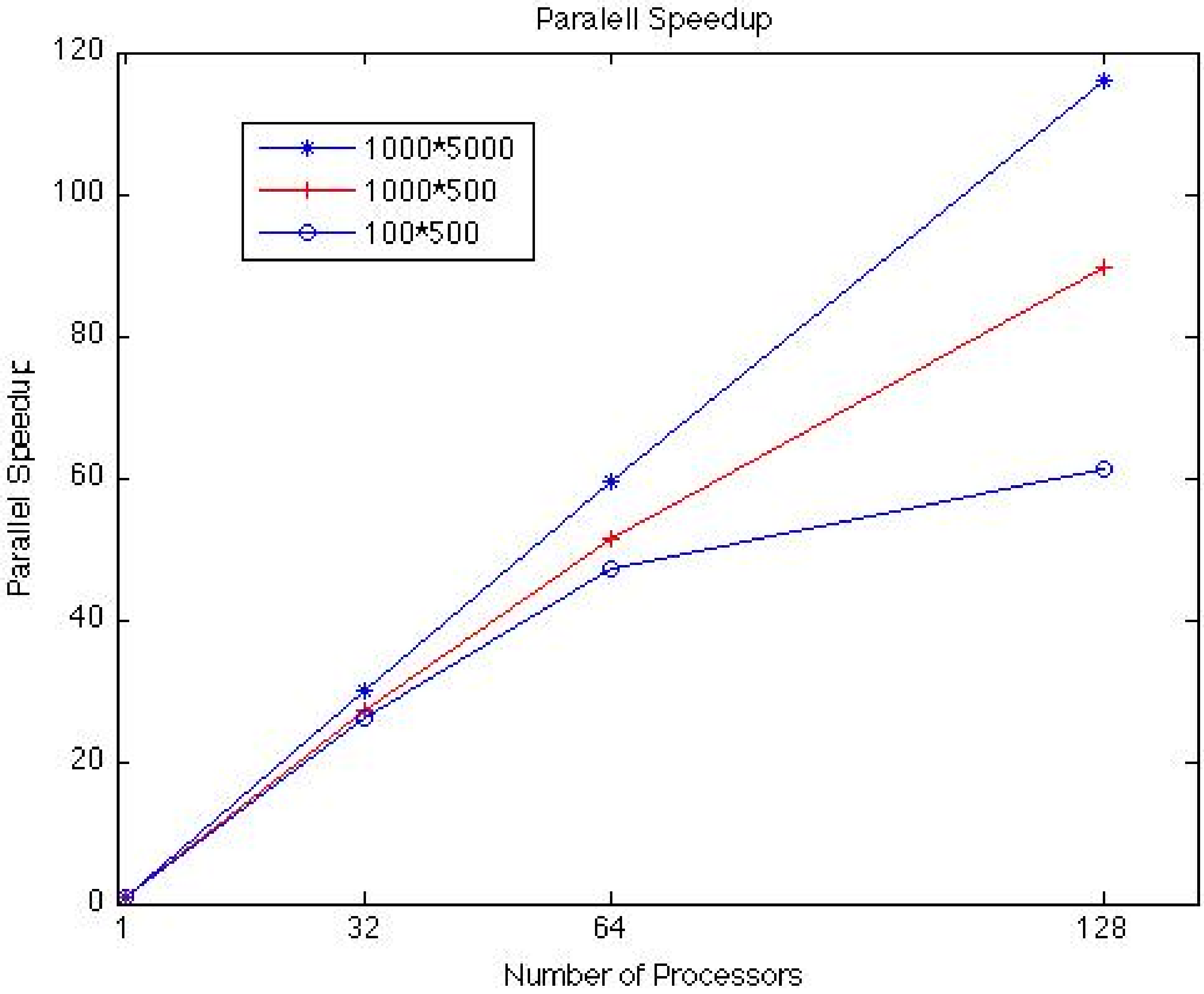
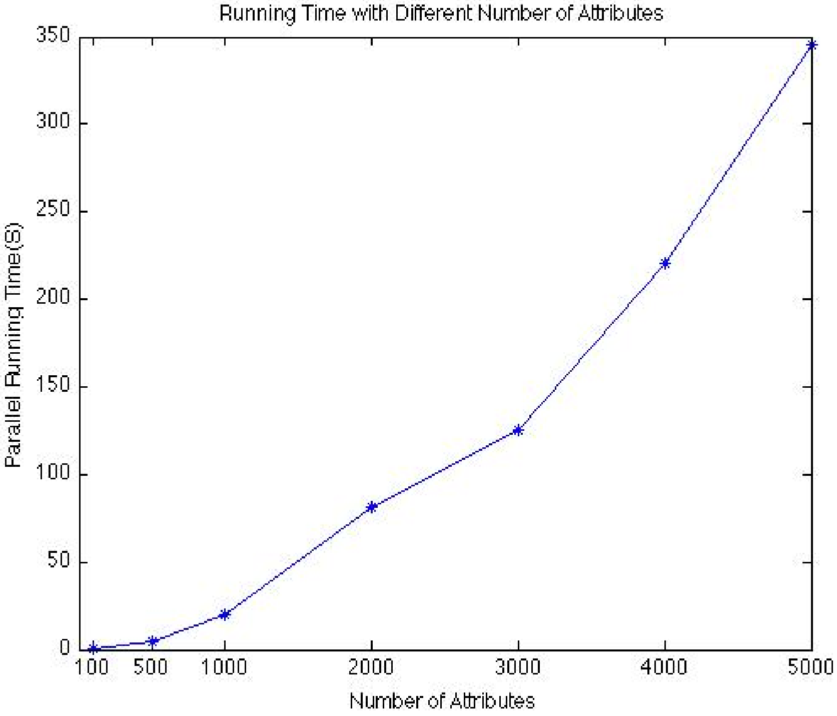
# of attributes = 5000, # of samples = 1000

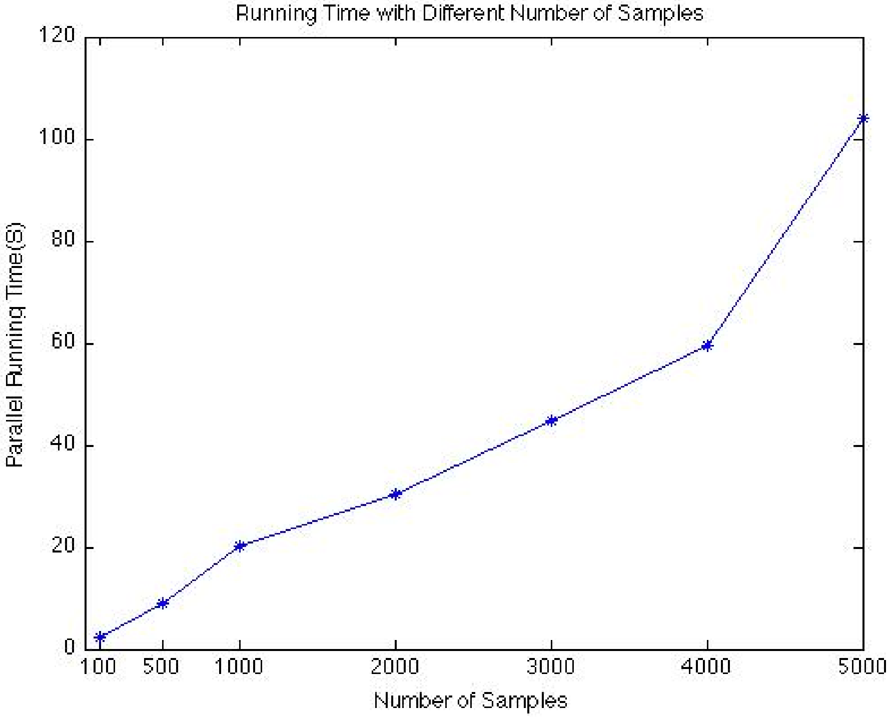
Parallel Speedup VS Dataset Size



Running Time VS Dataset Size



# of nodes = 128
# of samples = 1000



# of nodes = 128
# of attributes = 1000

Thank you!