# High Performance Computing

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## Work-Span Model

We represent a computation using a DAG (Directed Acyclic Graph)

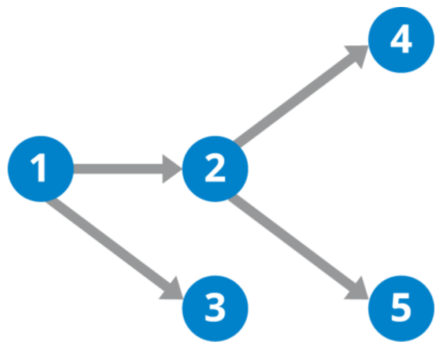


Figure 1: DAG

Each node represents an operation and the edges represent what operations should be done before. Suppose:

1. Each operation is made in the same time.
2. Each operation takes a unit of time.
3. No edge cost.

Define:

$$\begin{aligned} W(n) &= \text{ Total number of nodes.} \\ D(n) &= \text{ Vertices on the longest path.} \\ T_p(n) &= \text{ Time to execute given that we have pram procesors.} \end{aligned}$$

We want to know an upper bound for $T_p(n)$, we already know the following:

$$\begin{aligned} T_1(n) &= W(n) \\ T_\infty(n) &= D(n) \\ T_p(n) &\geq max\{D(n), \left\lceil \frac{W(n)}{p} \right\rceil\} \end{aligned}$$

### Brent's Theorem

Let's suppose given a DAG we break it into phases, where:

1. Each phase has 1 c.p. vertex.
2. All vertices in a given phase are independent.
3. Every vertex has to appear in some phase (phase $k$ has $W_k$ vertices and takes $t_k$ time to complete).

then:

$$
\begin{aligned}
T_p &= \sum_{k=1}^{D} t_k \\
&= \sum_{k=1}^{D} \left\lceil \frac{W_k}{p} \right\rceil \\
&= \sum_{k=1}^{D} \left\lfloor \frac{W_k - 1}{p} \right\rfloor + 1 \\
&= \sum_{k=1}^{D} \frac{W_k - 1}{p} + 1 \\
&\leq \tfrac{W-D}{p} + D
\end{aligned}
$$

Given a DAG we can see his performance with:

$$S_p(n) = \frac{T_*(n)}{T_p(n)} \text{ where } T_*(n) \text{ is best sequential time.}$$