Pointer Jumping Techniques
(working with linked lists)

Note: This should be done briefly in about 1 lecture.

Input: A linked list arbitrarily distributed throughout the memory of the model under consideration. Each node has a data field and a **next** field. The next field of the last element in the list has its next field set to **nil**.

1. RAM: the list is distributed arbitrarily throughout memory, where the location of the first element is known
2. PRAM: the list is distributed arbitrarily throughout the shared memory, where every processor is associated with an element. The processor associated with the first element in the list, knows that.
3. Network models: the list is distributed arbitrarily among the processors

Draw example for class and discuss the differences in the models.

RAM: Discuss pointer jumping (lack of it) on a RAM. Discuss sequential search/computation for basic operations

1. search/traversal
2. parallel prefix
3. component labeling

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List Ranking

Demonstrate pointer jumping by the *list ranking problem*: Given a linked list L of n objects, determine the distance to the end of the list for every element. Therefore,

$$d(i) = \begin{cases} 0 & \text{if } next(i) = nil \\ 1 + d(next(i)) & \text{if } next(i) \neq nil \end{cases}$$

Initialize $d(i) \leftarrow 0$ if $next(i) = nil$
$d(i) \leftarrow 1$ if $next(i) \neq nil$

While $\exists i \ni next(i) \neq nil$ do

Forall P_i do

if $next(i) \neq nil$ then $\begin{cases} d(i) \leftarrow d(i) + d(next(i)) \\ next(i) \leftarrow next(next(i)) \end{cases}$

Time: $\Theta(\log n)$
Discuss time/processor tradeoffs

Note that list ranking procedure can be used to label components in a forest.

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Parallel Prefix

Parallel Prefix: Given $x_1, x_2, ..., x_n$ and a binary associative operator $\otimes$, compute $x_1, x_1 \otimes x_2, x_1 \otimes x_2 \otimes x_3, ...$ where the k^{th} item $x_1 \otimes x_2 \otimes ... \otimes x_k$ is called the k^{th} prefix.

Given a linked list L of n objects on an n-processor EREW PRAM:

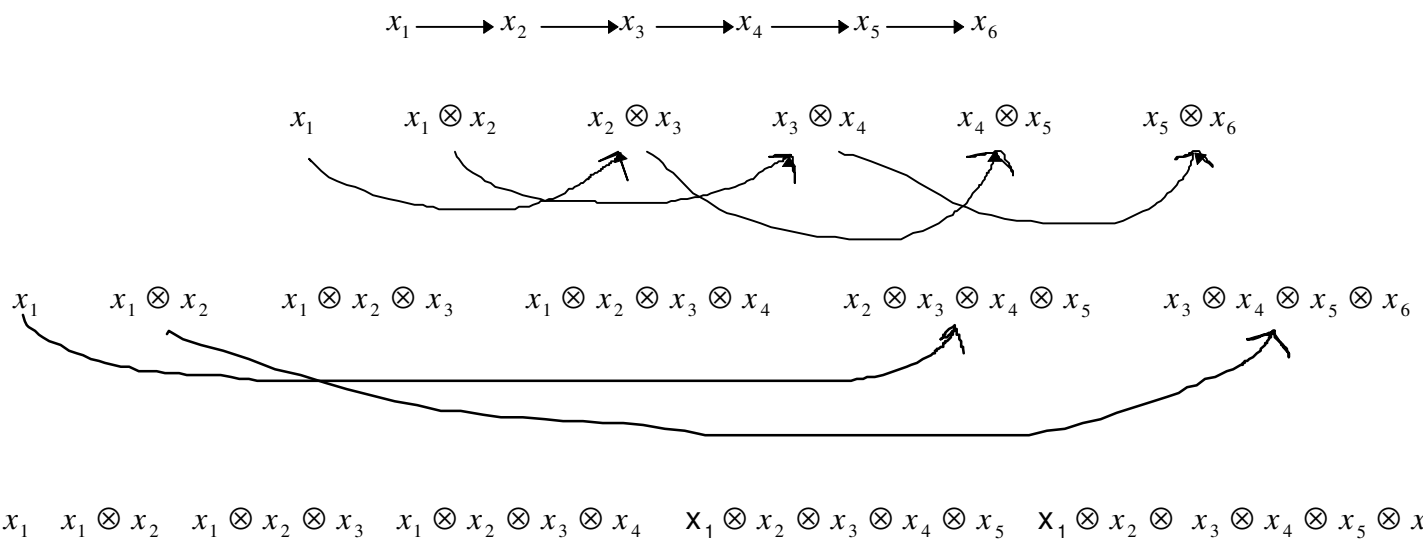
$y(i) \leftarrow x(i)$ {y is used to store results}

while there exists an i such that $next(i) \neq nil$ do

Forall P_i do

if $next(i) \neq nil$ then $y(next(i)) \leftarrow y(i) \otimes y(next(i))$

$next(i) \leftarrow next(next(i))$



x_1 $x_1 \otimes x_2$ $x_1 \otimes x_2 \otimes x_3$ $x_1 \otimes x_2 \otimes x_3 \otimes x_4$ $x_1 \otimes x_2 \otimes x_3 \otimes x_4 \otimes x_5$ $x_1 \otimes x_2 \otimes x_3 \otimes x_4 \otimes x_5 \otimes x$

Time: $\Theta(\log n)$

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