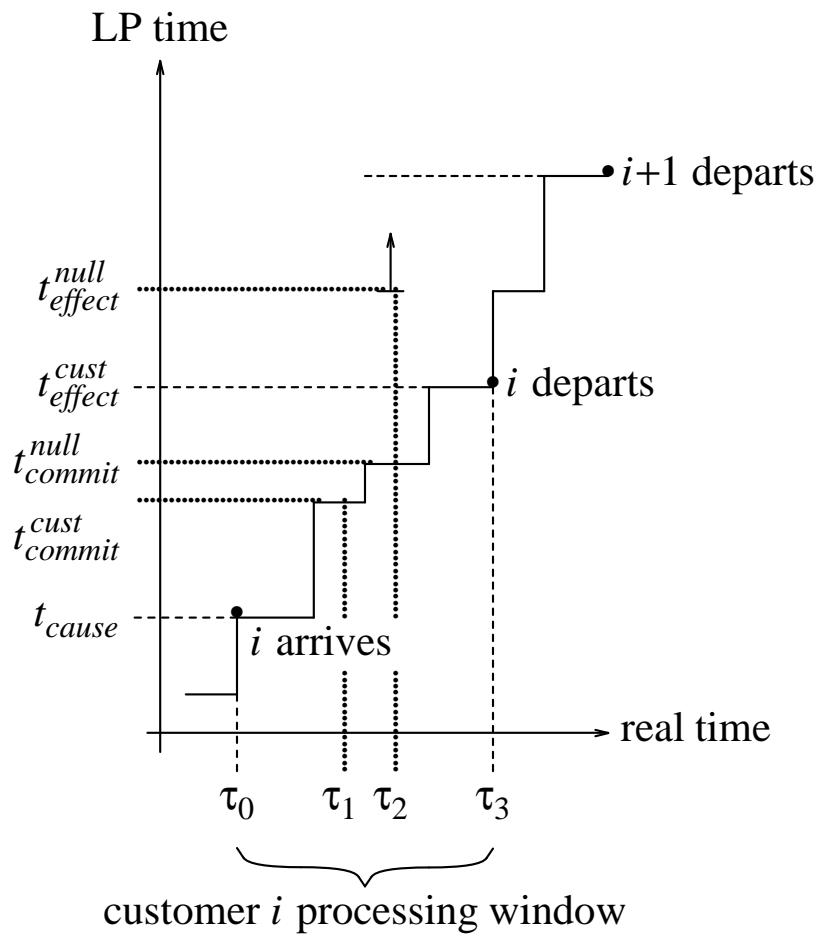
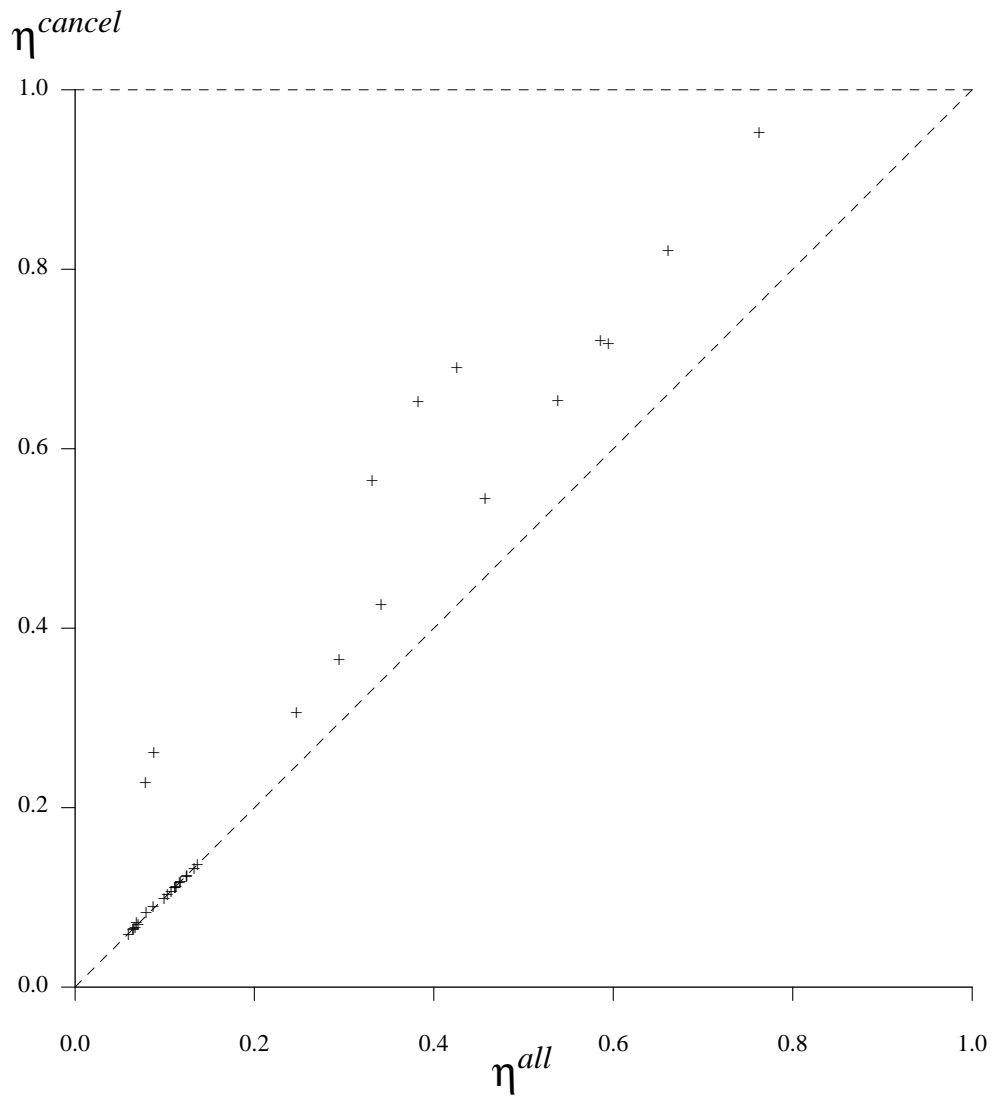


**Null Message Cancellation  
in Conservative Distributed Simulation**

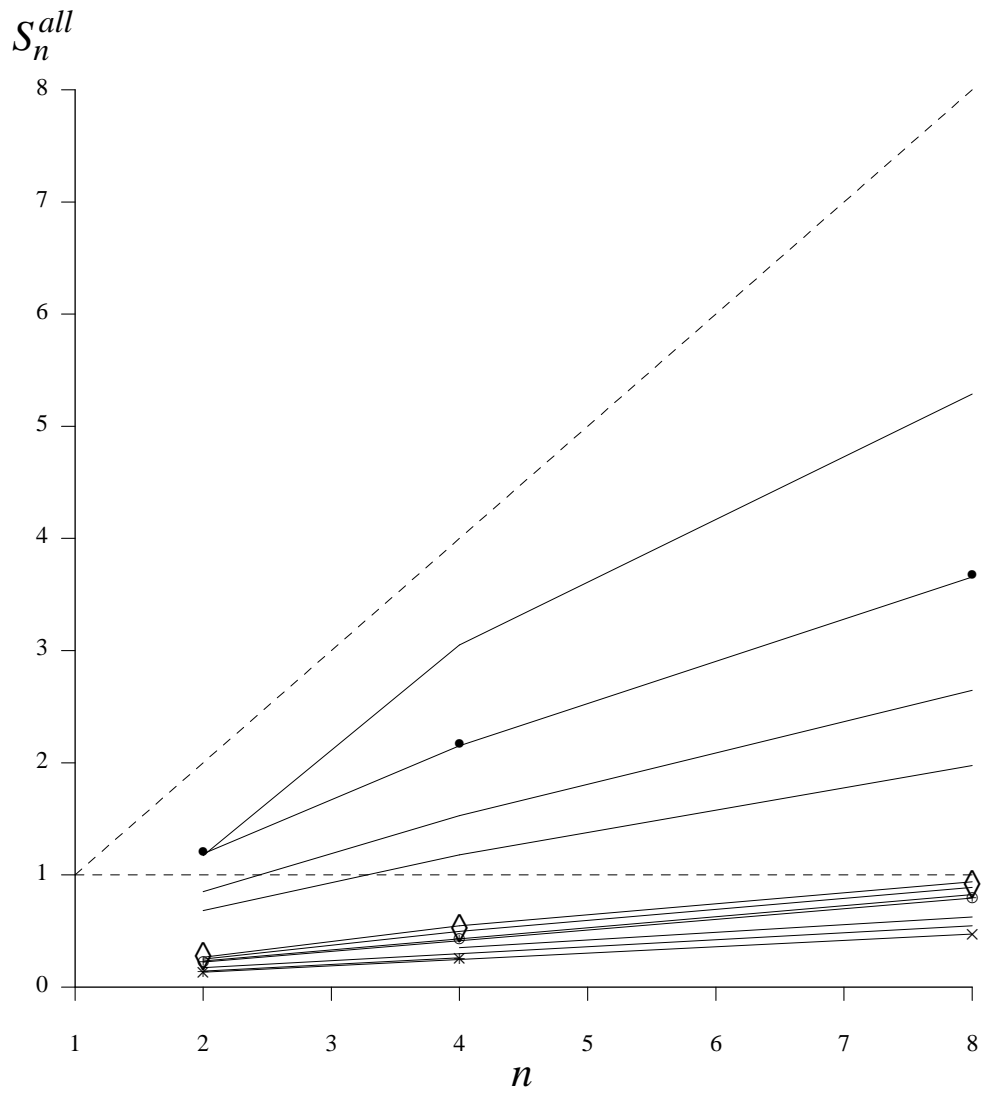
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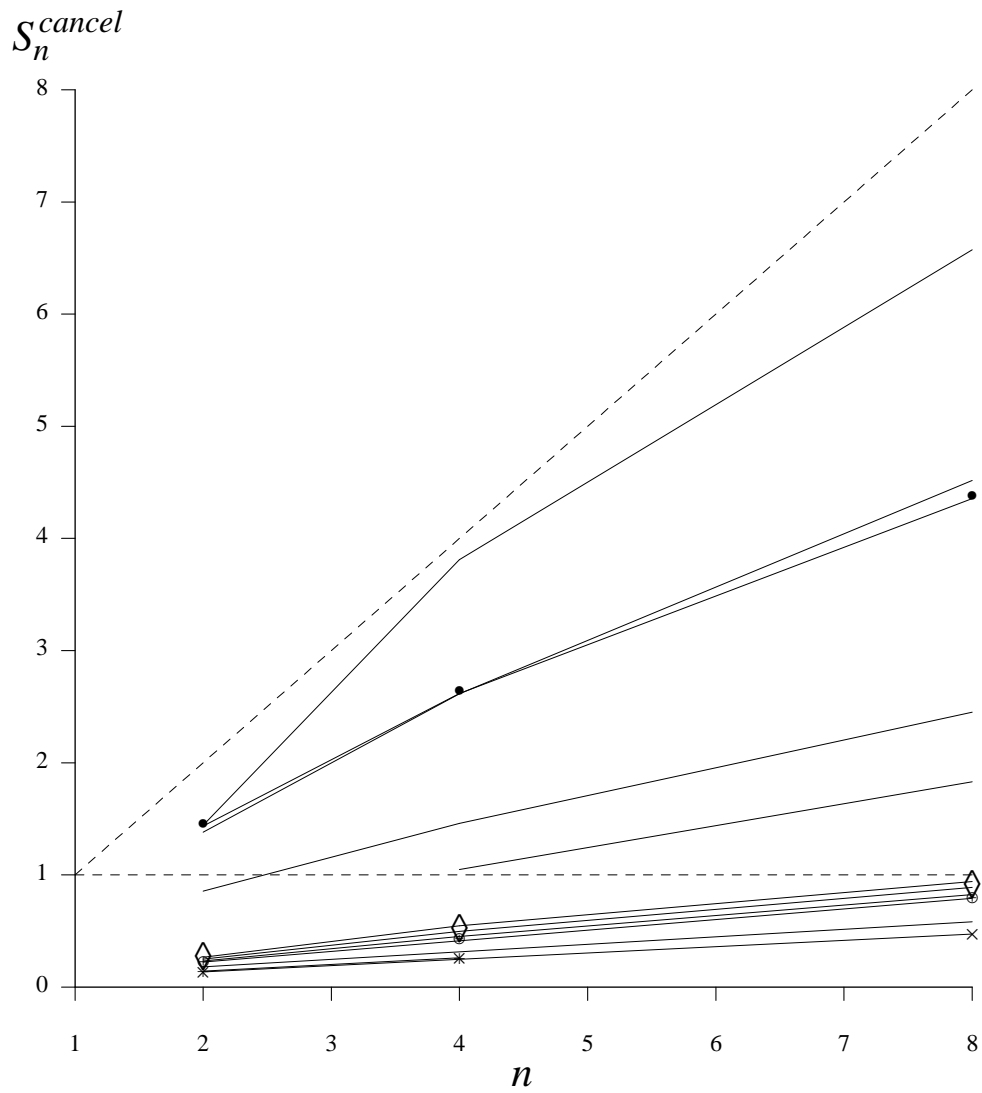




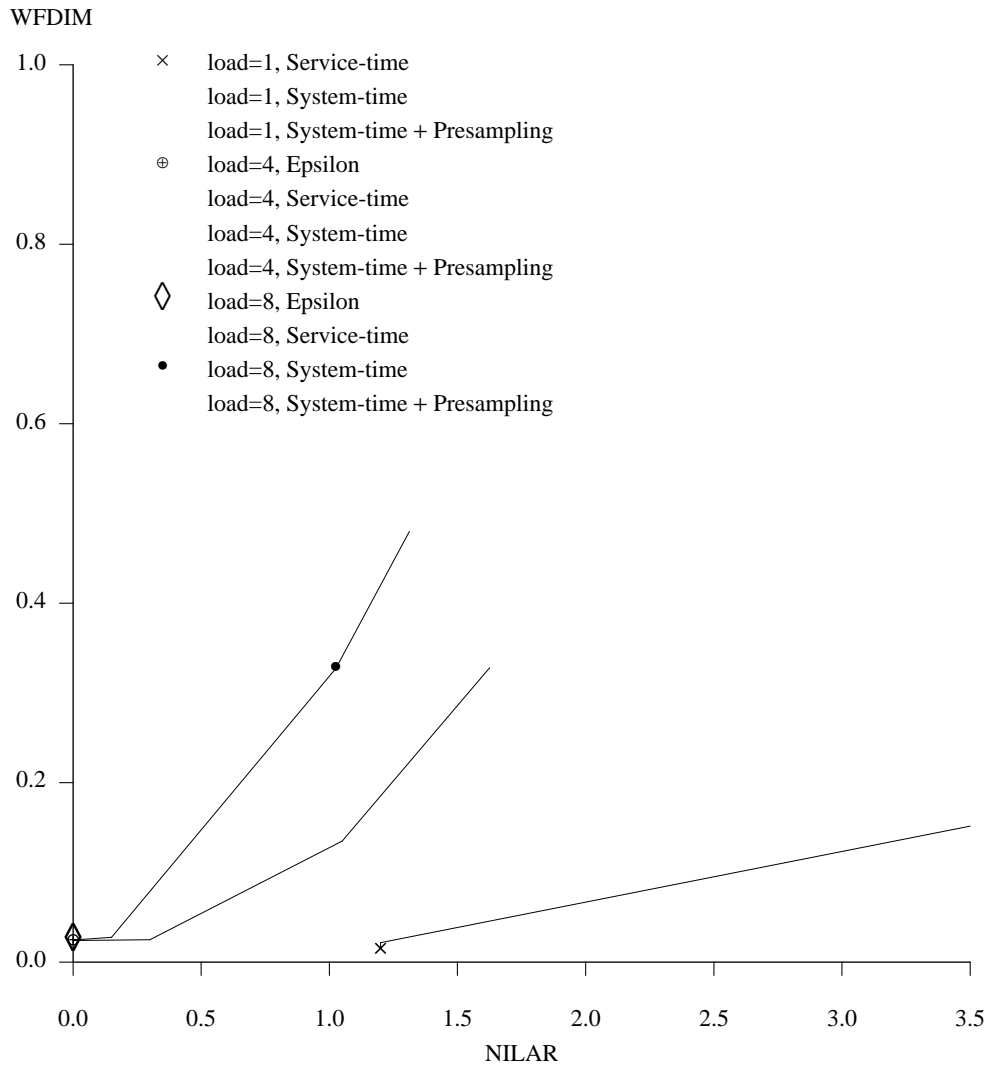
Efficiency vs. Efficiency.



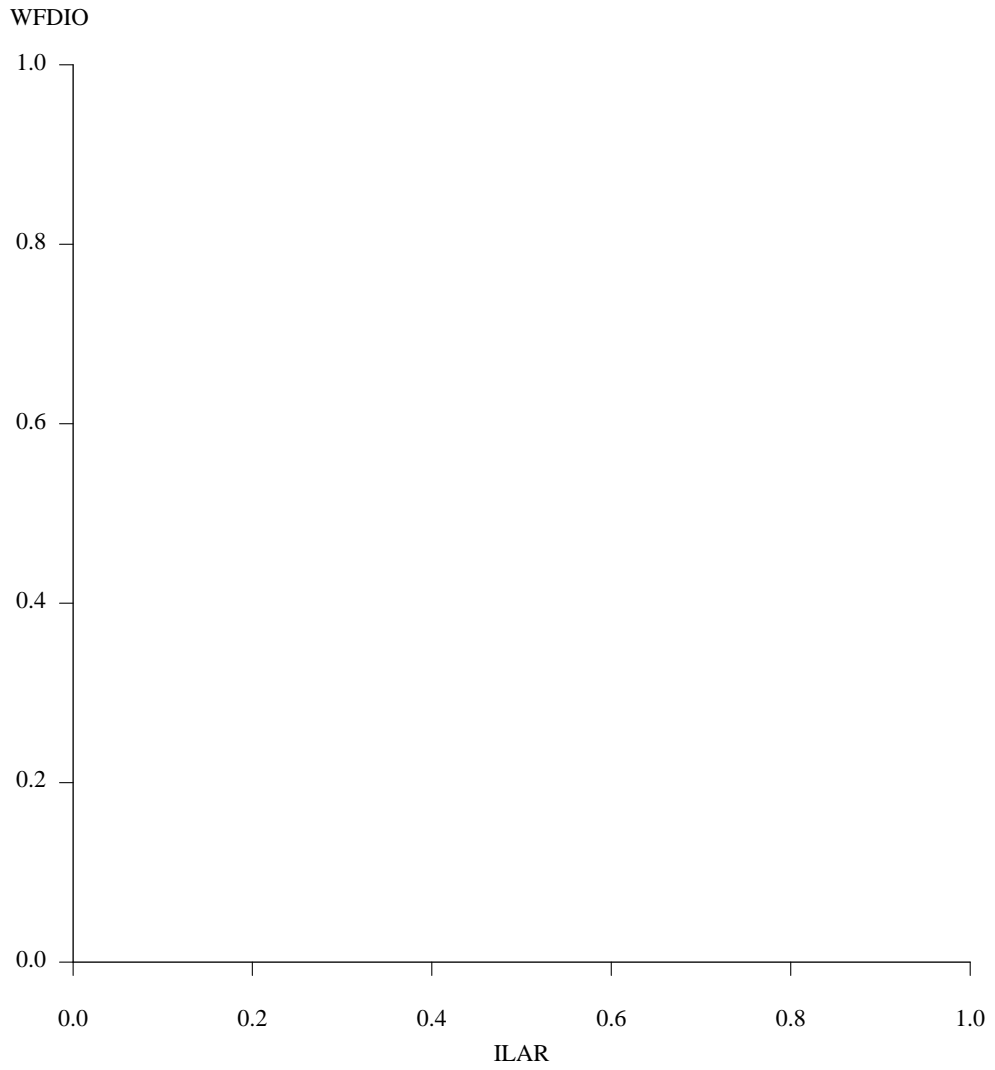
Speedup vs. Processors (no cancellation).



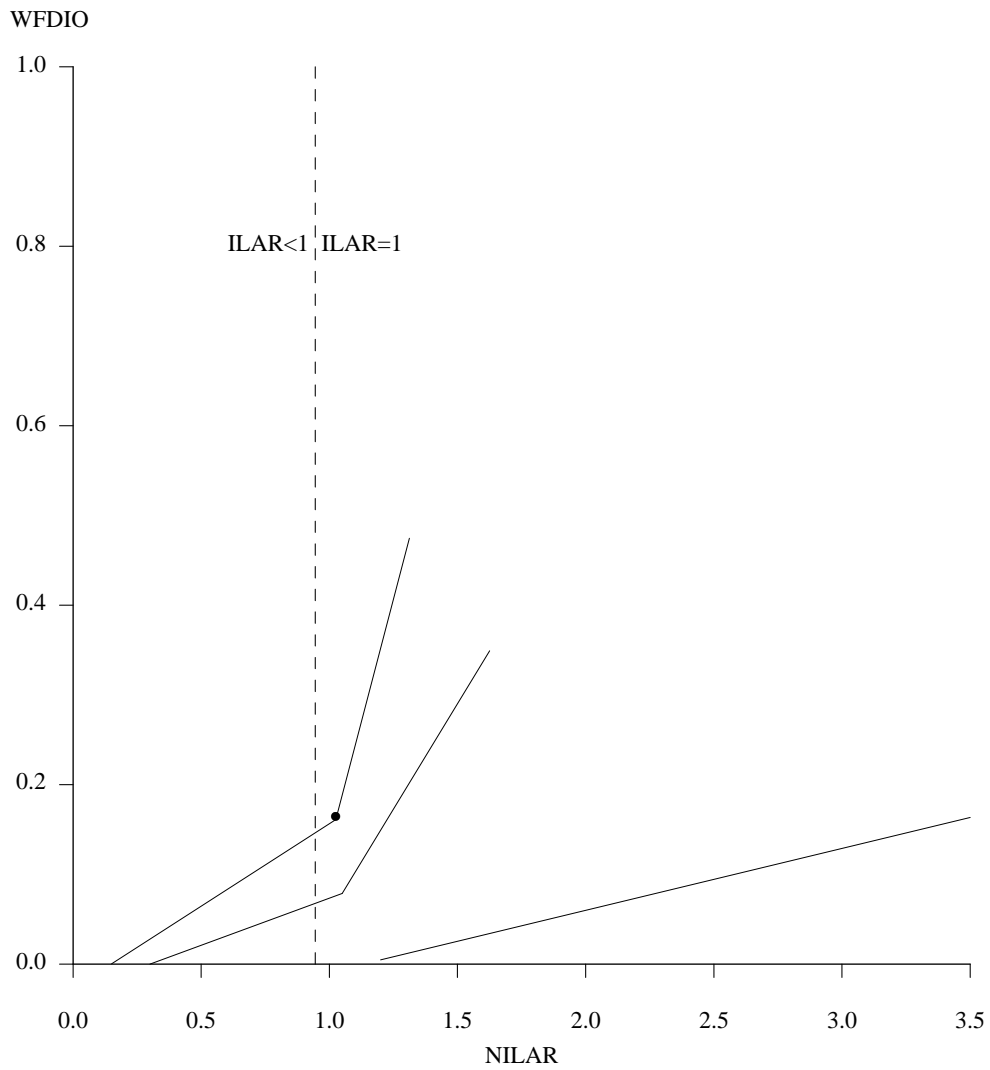
Speedup vs. Processors (with cancellation).



WFDIM vs. NILAR, processors=8.



WFDIO vs. ILAR.



WFDIO vs. NILAR, processors=8.

**Table I**  
**Characteristic Message Times Upon Customer Arrival**

model	$t_{effect}^{null}$	$t_{commit}^{cust}, t_{commit}^{null}$
epsilon	$t_{effect}^{cust}$	$t_{cause} + t_{queueing} + t_{service} - \epsilon$
service time	$t_{effect}^{cust} + \mu_{min}$	$t_{cause} + t_{queueing}$
system time	$t_{effect}^{cust} + \mu_{min}$	$t_{cause}$
system time + presampling	$t_{effect}^{cust} + t_{prediction}$	$t_{cause}$

**Table II**  
**Characteristic Message Times Upon Null Message Arrival**

model	$t_{effect}^{null}$	$t_{commit}^{null}$
epsilon	$t_{cause} + 2\epsilon$	$t_{cause}$
service time	$t_{cause} + \mu_{min}$	$t_{cause}$
system time	$t_{cause} + \mu_{min}$	$t_{cause}$
system time + presampling	$t_{cause} + t_{prediction}$	$t_{cause}$

**Table III**  
**Lookahead Models**

null message lookahead	customer lookahead		
	$\epsilon$	$t_{service}$	$t_{queueing} + t_{service}$
$\epsilon$	epsilon	–	–
$t_{service} + \mu_{min}$	–	service time	–
$t_{queueing} + t_{service} + \mu_{min}$	–	–	system time
$t_{queueing} + t_{service}$ $+ t_{prediction}$	–	–	system time + presampling

**Table IV**

model	ILAR	NILAR
epsilon	$\frac{\epsilon/\mu}{N}$	$\frac{2\epsilon/\mu}{N}$
service time	$\frac{1}{N}$	$\frac{1+\mu_{min}/\mu}{N}$
system time	1	$\frac{N+\mu_{min}/\mu}{N}$
system time + presampling	1	$\frac{N+f_{out}}{N}$

## Lookahead Ratios

- The inverse lookahead ratio (ILAR) for an LP is given by

$$ILAR = \frac{E[t_{effect}^{cust} - t_{commit}^{cust}]}{E[t_{effect}^{cust} - t_{cause}]}, \quad (1)$$

where the expectation is taken over all customers.

- The null message inverse lookahead ratio (NILAR) for an LP is given by

$$NILAR = \frac{E[t_{effect}^{null} - t_{commit}^{null}]}{E[t_{effect}^{cust} - t_{cause}]}, \quad (2)$$

where the expectation is taken over all null messages *sent in association with customers*. (Note the use of  $t_{effect}^{cust}$  in the denominator of NILAR.)

## Execution Time Overhead

- The overhead associated with the parallel execution of the simulation without null message cancellation is  $O^{all} = T_n^{all} - T_1/n$ .
- The overhead *with* null message cancellation is  $O^{cancel} = T_n^{cancel} - T_1/n$ .
- The fractional decrease in overhead due to null message cancellation is given by

$$\frac{\Delta O}{O^{all}} = \frac{O^{all} - O^{cancel}}{O^{all}} = \frac{T_n^{all} - T_n^{cancel}}{T_n^{all} - T_1/n}. \quad (3)$$

- Thus, the *weighted* fractional decrease in overhead (WFDIO) is given by

$$WFDIO = \frac{T_n^{all} - T_n^{cancel}}{T_n^{all} - T_1/n} \eta^{cancel} = \frac{\eta^{cancel} - \eta^{all}}{1 - \eta^{all}}, \quad (4)$$

where  $\eta^{cancel} = T_1/n T_n^{cancel}$ , and  $\eta^{all} = T_1/n T_n^{all}$ ,

- WFDIO can also be interpreted as the change in efficiency due to null message cancellation,  $\eta^{cancel} - \eta^{all}$ , divided by the *potential* improvement in efficiency,  $1 - \eta^{all}$ .

## Message Count Overhead

- WFDIM is the ratio of the *difference* in the number of null messages between parallel simulation with and without null message cancellation (actual improvement) to the number of null messages required without null message cancellation (potential improvement) weighted by the resulting parallel efficiency.

$$WFDIM = \frac{M_n^{all} - M_n^{cancel}}{M_n^{all} - 0} \eta^{cancel}, \quad (5)$$

where  $M_n^{all}$  is the number of null messages required in the parallel simulation without null message cancellation, and  $M_n^{cancel}$  is the number of null messages required in the parallel simulation with null message cancellation.

## Conclusions

- Null message cancellation is a viable algorithmic modification to the conventional conservative synchronization method when coupled with an appropriately predictive LP implementation.
- ILAR alone is not a good indicator of the predictiveness of an LP.
- The results indicate that the more predictive an LP is with respect to null messages, the more likely it is to benefit from null message cancellation!

## A Simple Idea

real time

