

# Towards Soft Real-Time Applications on Enterprise Desktop Grids

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# Desktop Grids

Astronomy



67 TeraFlop/sec,  
500,000 active hosts,  
\$700,000

Biology



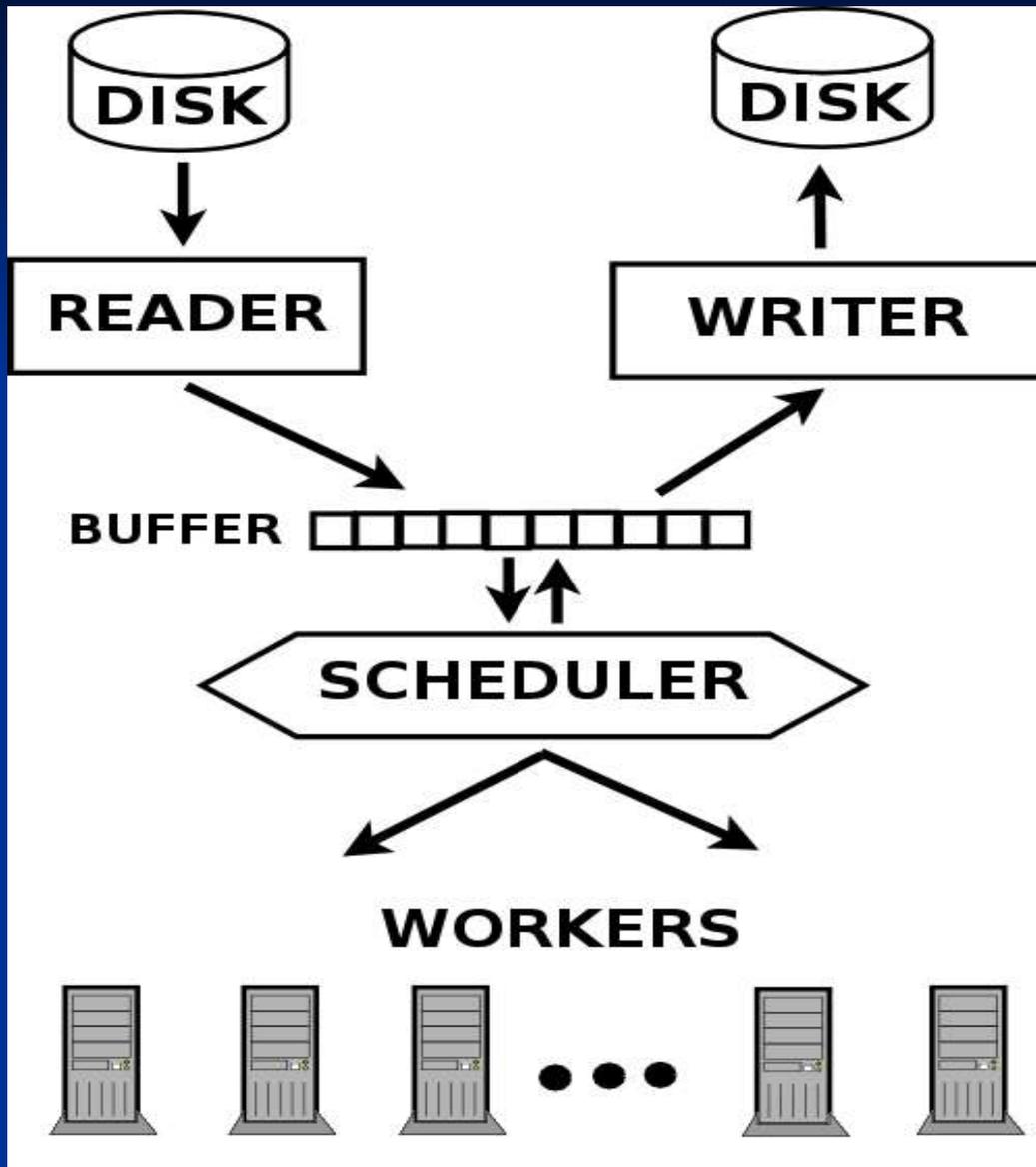
Math  
& Physics



# Motivation and Goal

- State of the art: high throughput, task-parallel applications
- Broaden applicability of desktop grids
- Allow soft-real time applications to utilize desktop grids
  - Online tomography, sensor networks, video encoding, interactive scientific visualization
  - Meet soft deadlines for task completion via buffering

# Problem Statement



$H$ : tasks per batch

$C_{in}$ : period that task batch  
is added to buffer

$b$ : buffer size

$d$ : task deadline

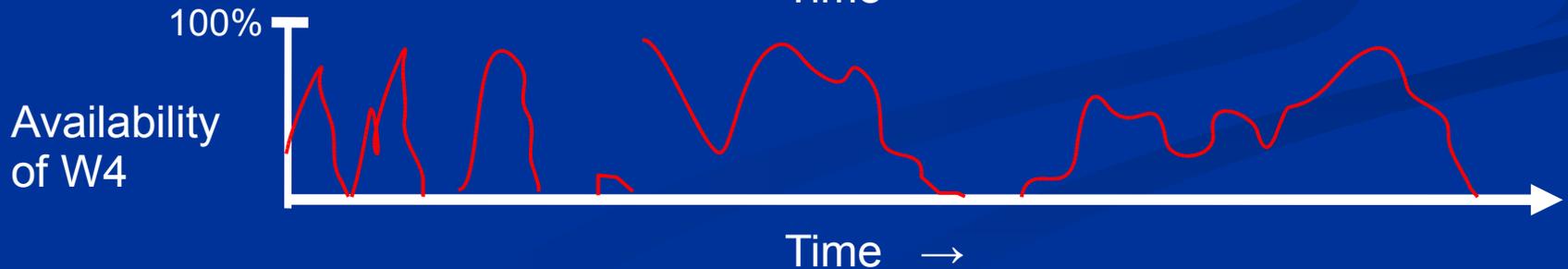
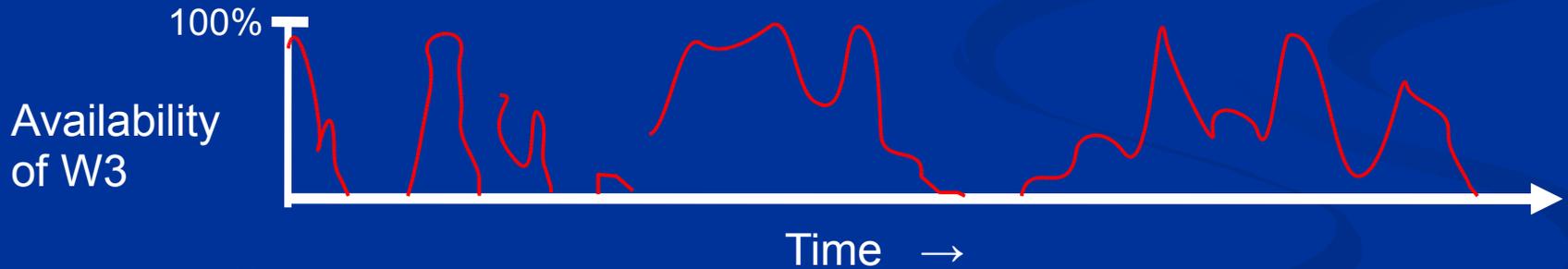
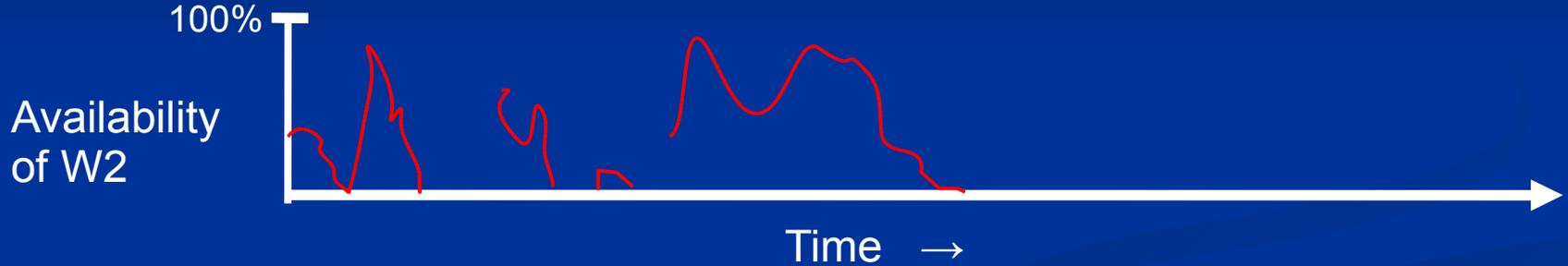
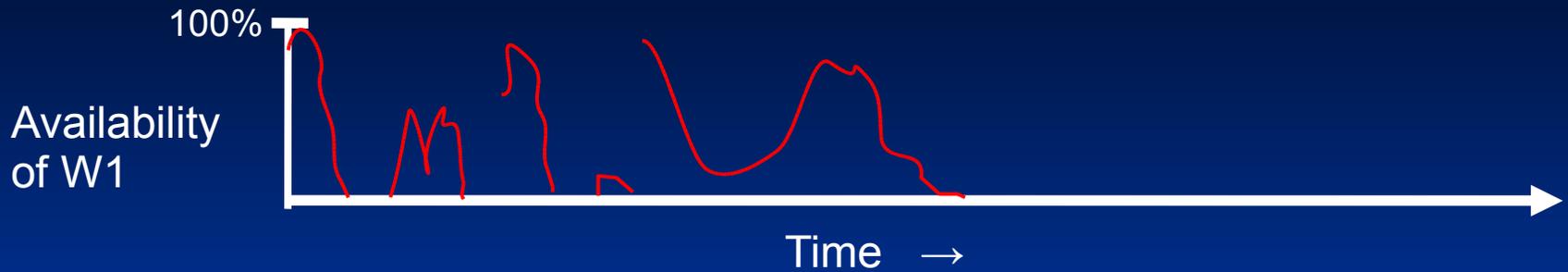
$$d = b * (C_{in} / H)$$

Performance metric:  
task success rate

# Approach

- Characterize the factors that effect task completion
- Construct model from characterization
- Show evidence that supports model via trace-driven simulation

# Characterization



# Characterization Of Aggregate Compute Power

$p_i^{t,t+\delta}$ : Compute power during  $[t$  and  $t + \delta]$  for worker  $i$

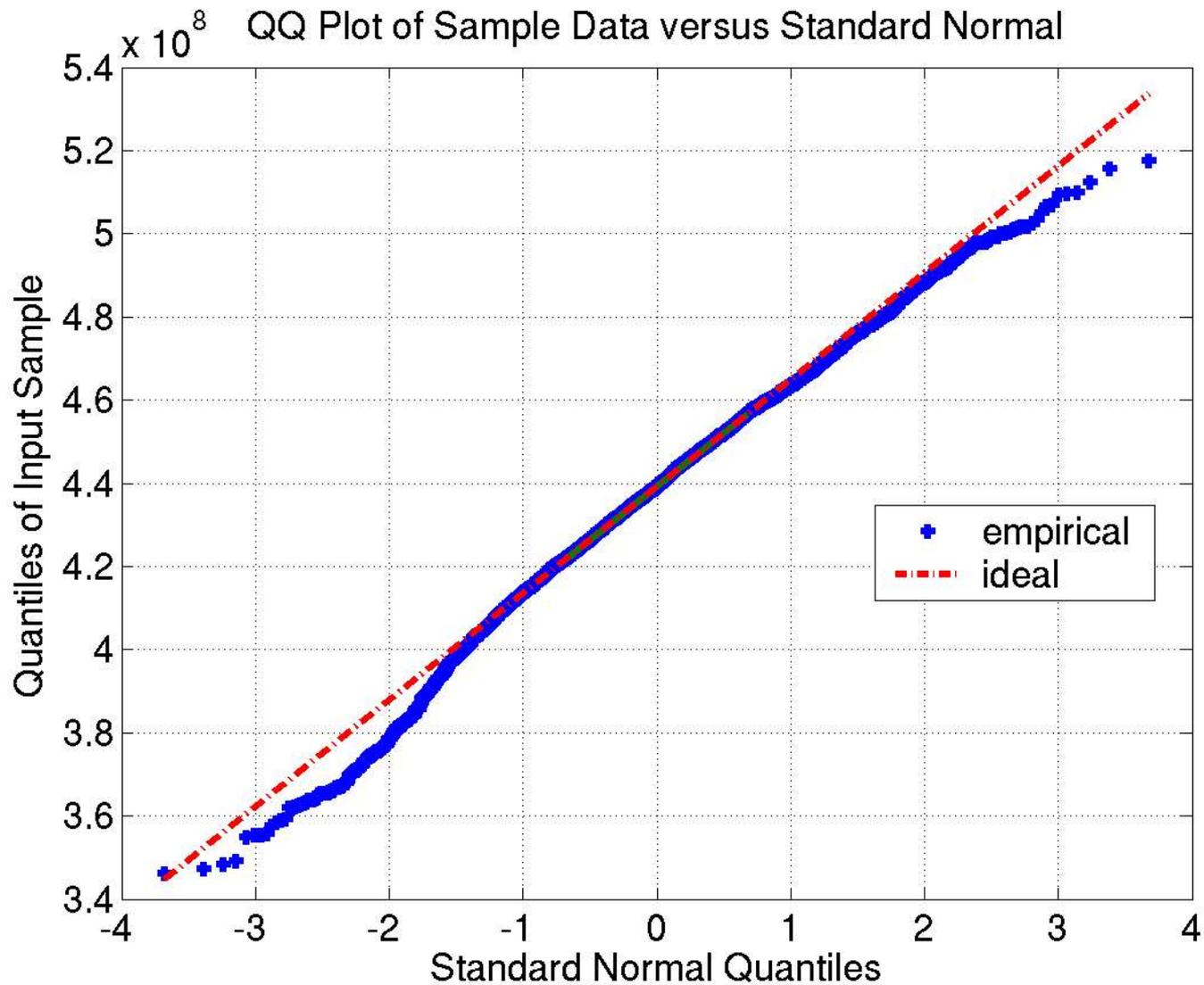
$P^{t,t+\delta} : \sum_{i=1}^N p_i^{t,t+\delta}$  where  $N$  is the # of workers

- $H_0$ : Aggregate compute power  $P^{t,t+\delta}$  follows a normal distribution
- Central Limit Theorem: sum of a set of variates from any distribution with finite mean and variance tends toward a normal distribution

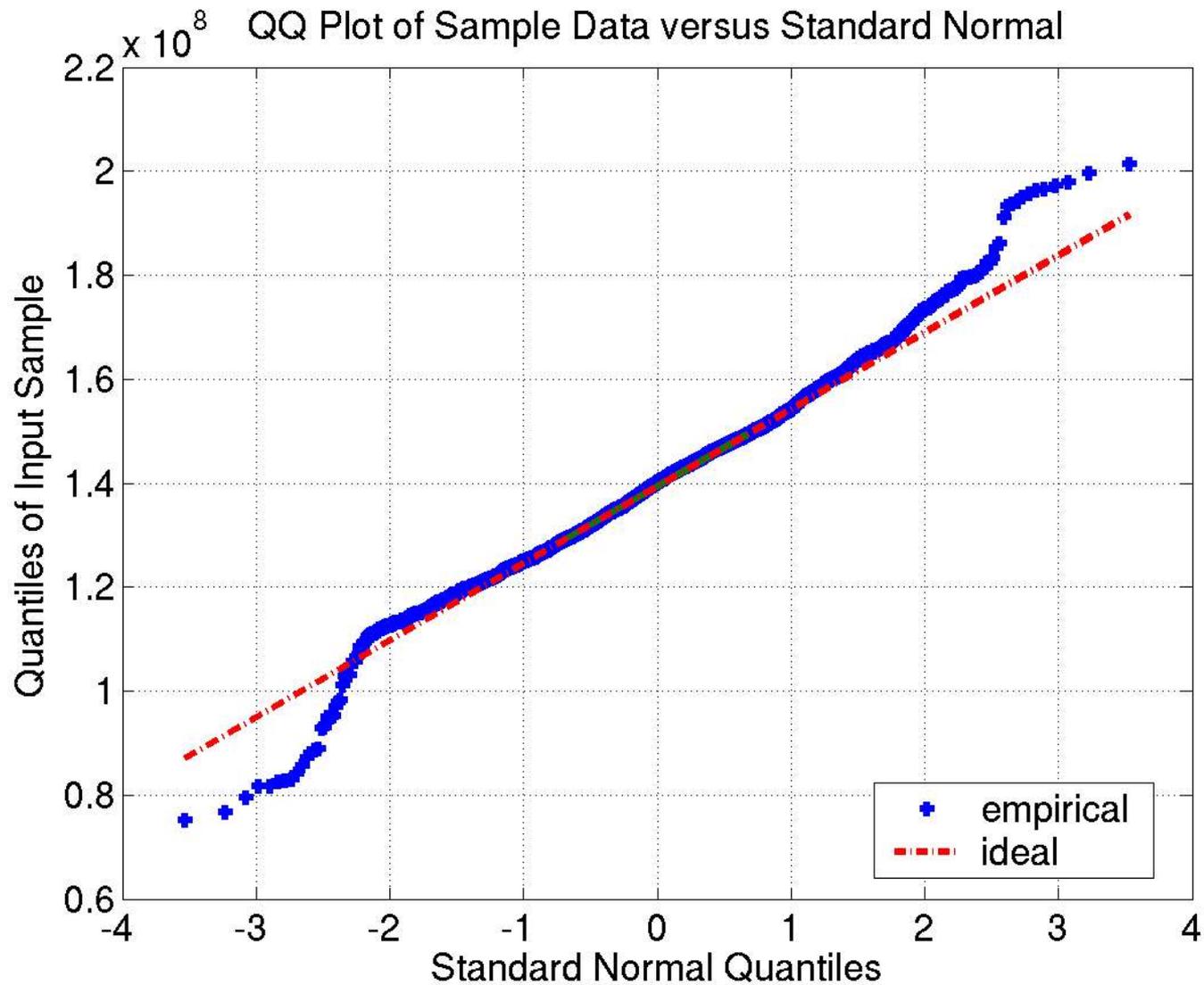
# Methodology

- Used two trace data sets: SDSC, UCB.
- Measured  $P^{t,t+\delta}$  at thousands of different values of  $t$  with  $\delta=60$  sec.
- Maximum likelihood estimation to determine parameter fit
  - SDSC:  $P^{t,t+\delta} \sim N(1.4*10^8, 1.56*10^7)$
  - UCB:  $P^{t,t+\delta} \sim N(4.8*10^8, 2.6*10^7)$

# UCB Quantile-Quantile Plot



# SDSC Quantile-Quantile Plot



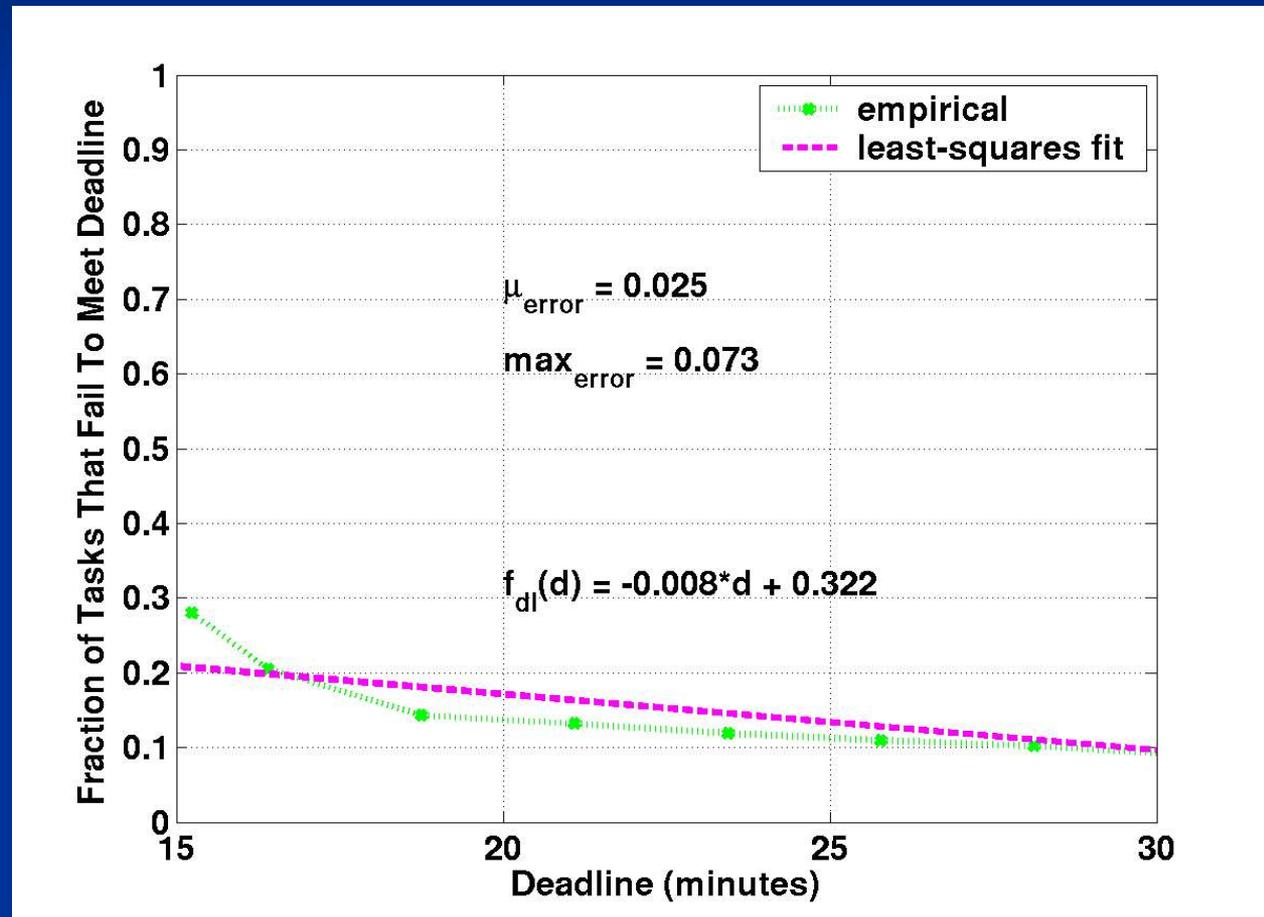
# Kolmogorov–Smirnov Goodness–of–fit Test

- Quantitative test
  - Intuition: reflects maximum difference between observed and expected cumulative distribution function (CDF)
- UCB: mean p–value: 0.466
- SDSC: mean p–value: 0.448

# Characterization of Deadline Failure Rates

$f_{dl}(d)$  : Fraction of tasks that fail to meet deadline  $d$

- Determine  $f_{dl}(d)$  using random incidence for 15-minute tasks for UCB



# Characterization of Deadline Failure Rates

$$f_{dl}(d) = -0.008 * d + 0.322$$

Since  $d = f(b) = (C_{in}/H) * b$ ,

$$f_{dl}(f(b)) = (-0.008 * C_{in} * b) / H + 0.322$$

# Modelling Task Success Rate

$$b \geq ((H * s) / (C_{in} * P^{t,t+\delta})) * H$$

where  $s$  is the size of the task in ops



$$b \geq (H^2 * s) / (C_{in} * P^{t,t+\delta})$$

$$Pr(P^{t,t+\delta} \geq \alpha) = Pr(P^{t,t+\delta} \geq (H^2 * s) / (C_{in} * b))$$

# Modelling Task Success Rate

$$Pr(P^{t,t+\delta} \geq \alpha) = Pr(P^{t,t+\delta} \geq (H^2 * s)/(C_{in} * b))$$

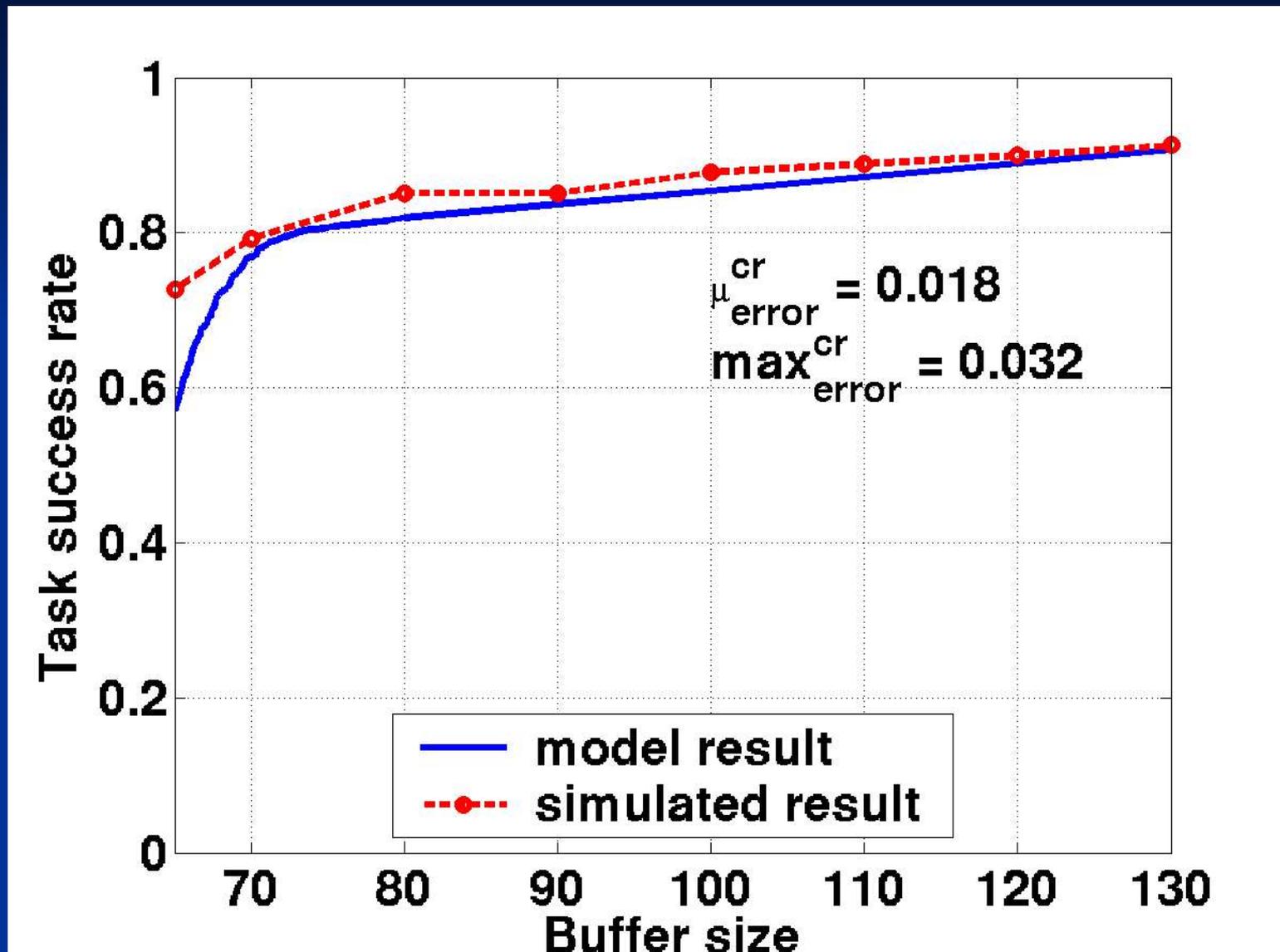
$$f_{dl}(f(b)) = (-0.008 * C_{in} * b)/H + 0.322$$

$$S(b) = Pr(P^{t,t+\delta} \geq \alpha) - f_{dl}(f(b))$$



$$S(b) = Pr(P^{t,t+\delta} \geq (H^2 * s)/(C_{in} * b)) - ((-0.008 * C_{in} * b)/H + 0.322)$$

# 15m-Task Success Rate Versus Buffer Size on UCB



# Related Work

- Characterization
  - CCGrid05\_Wolski: model host availability intervals
- Soft real-time scheduling
  - PDPTA99\_Dinda: Use different notion of availability, and hosts less volatile

# Summary

- Characterized desktop grids
  - Showed that aggregate computer power can be modelled as a normal distribution
  - Showed that deadline task failure rate can be modelled as a linear function
- Created closed-form model of task success rate as a function of buffer size
- Compared accuracy with simulated results

# Current and Future Work

- Implement in XtremWeb
- Extend applicability of desktop grids
  - Soft-real time applications
    - Timely data transfers