



# LAZY SHADOWING: A SCALABLE, ENERGY-AWARE RESILIENCE FRAMEWORK FOR EXTREME-SCALE SYSTEMS



XIAOLONG CUI, RAMI MELHEM, AND TAIEB ZNATI

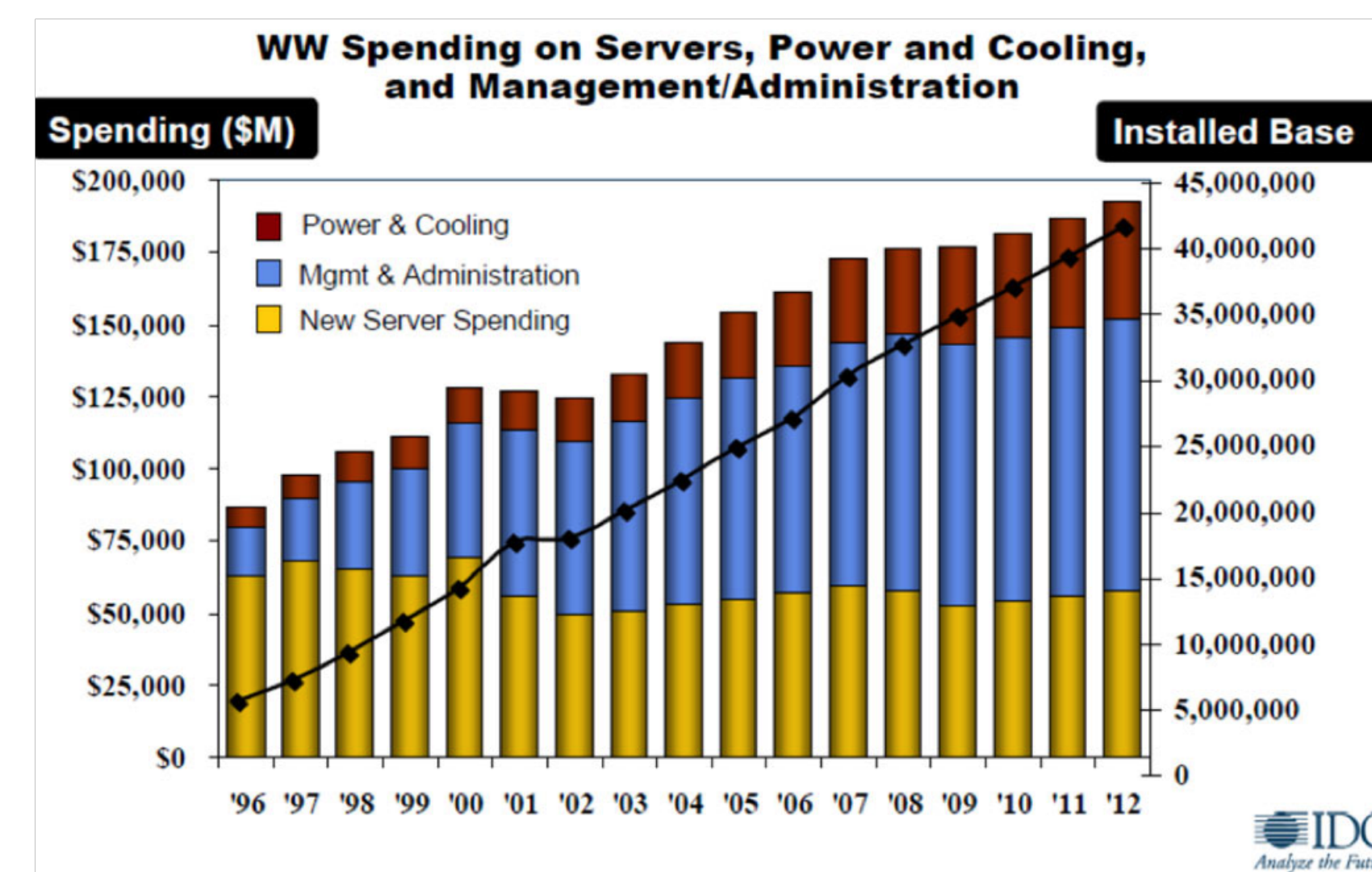
## PROBLEM

As the demand for computing capability continues to increase, there will be a multifold increase in the number of computing, storage and communication components in large scale systems, such as HPC supercomputers and cloud data centers. This increase has two direct implications:

1. Increased failure rate
2. Increased energy consumption

Number of nodes	Projected System MTBF
1	5 years
10	6 months
100	20 days
1000	2 days
10000	4 hours
100000	25 minutes

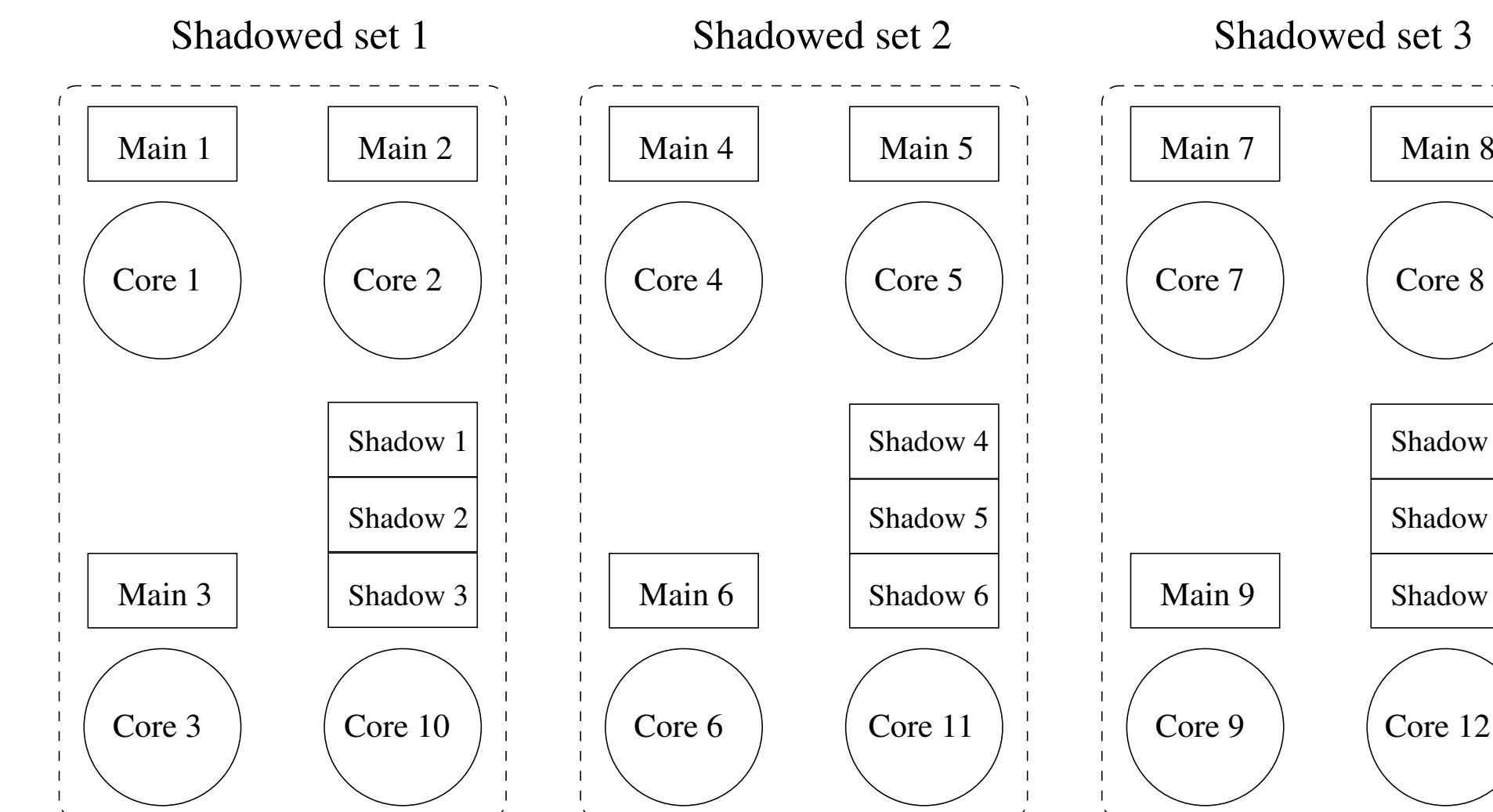
Failure



Energy

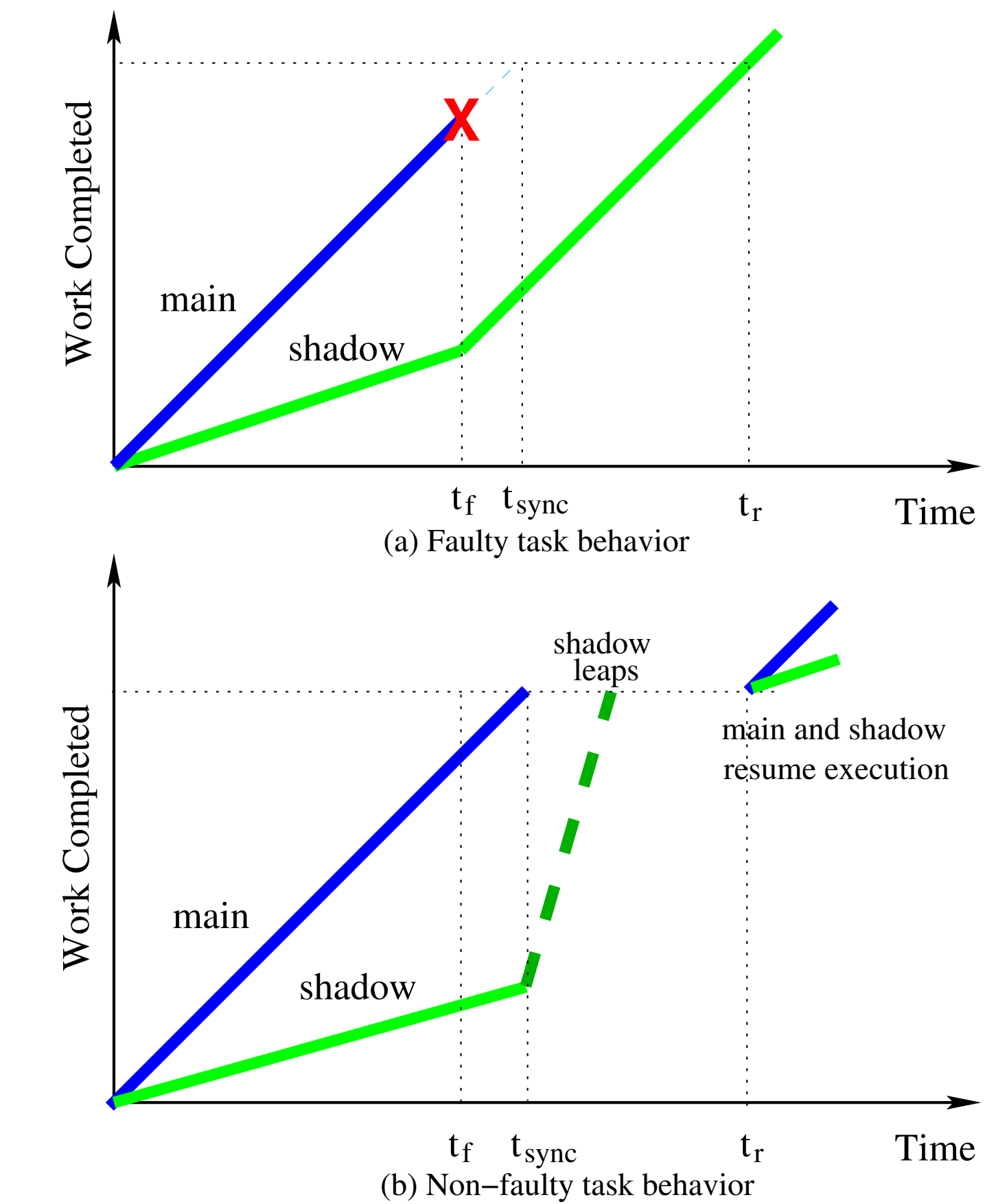
## IMPLEMENTATION

**Collocation** is used to achieve the desired execution rates of the shadow processes.



An example of collocation.

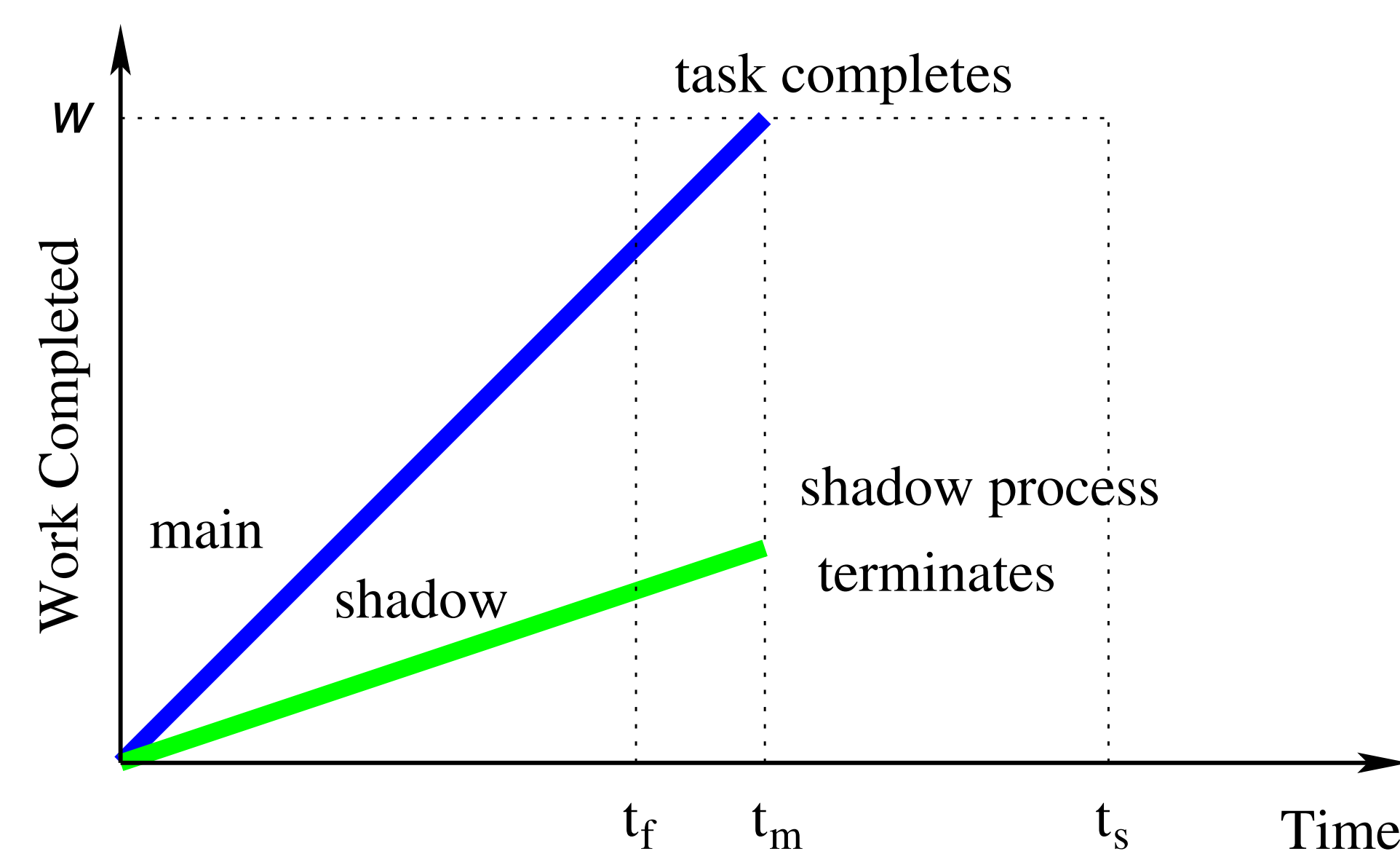
**Leaping Shadows** is an optimization for tightly-coupled parallel applications.



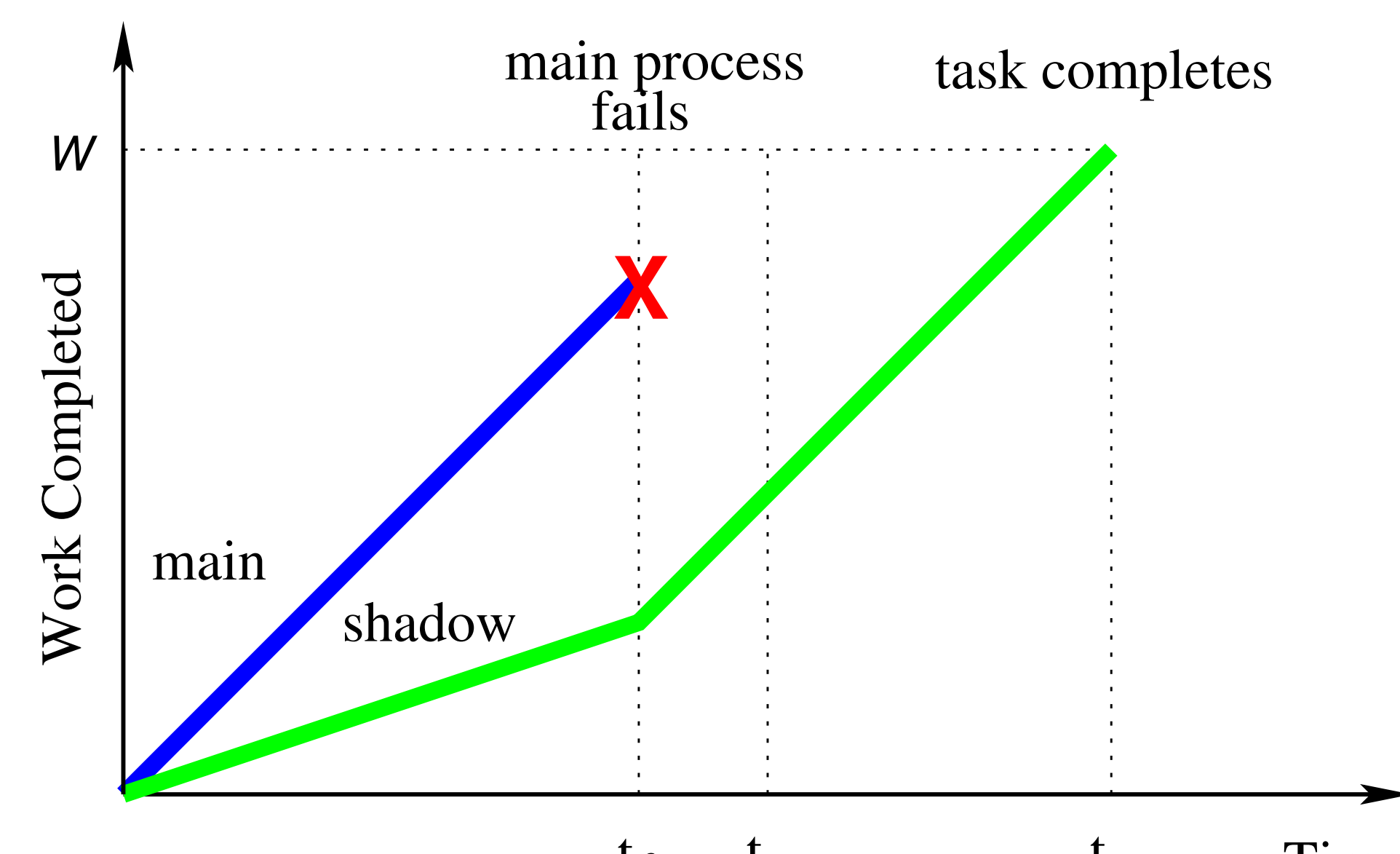
Leaping shadows.

## METHOD

The basic tenet of Lazy Shadowing is to associate with each main process a suite of shadow processes, whose size depends on the criticality of the application and the reliability of the underlying system. The shadows execute simultaneously with the mains, but at a slower speed to save energy.



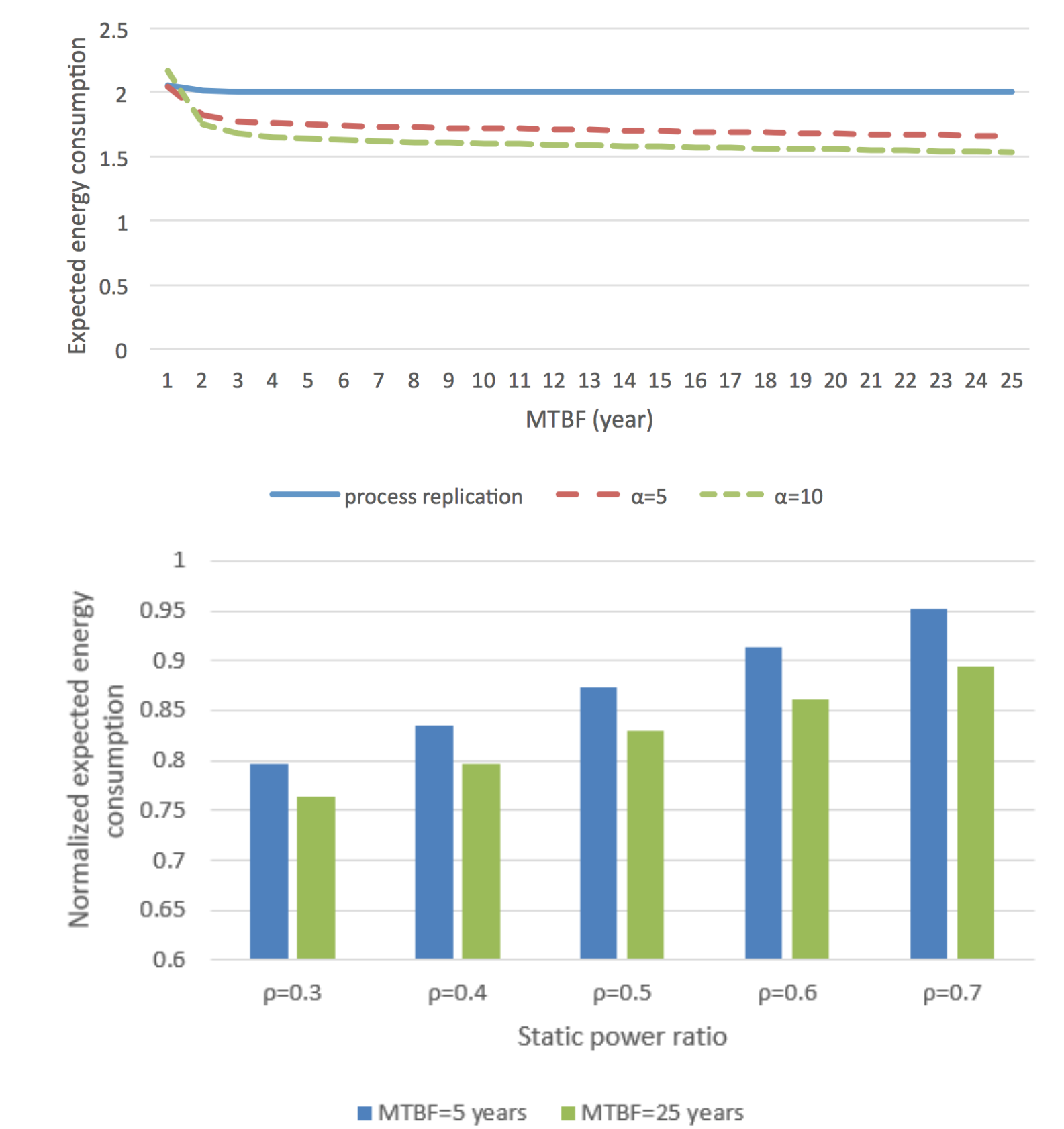
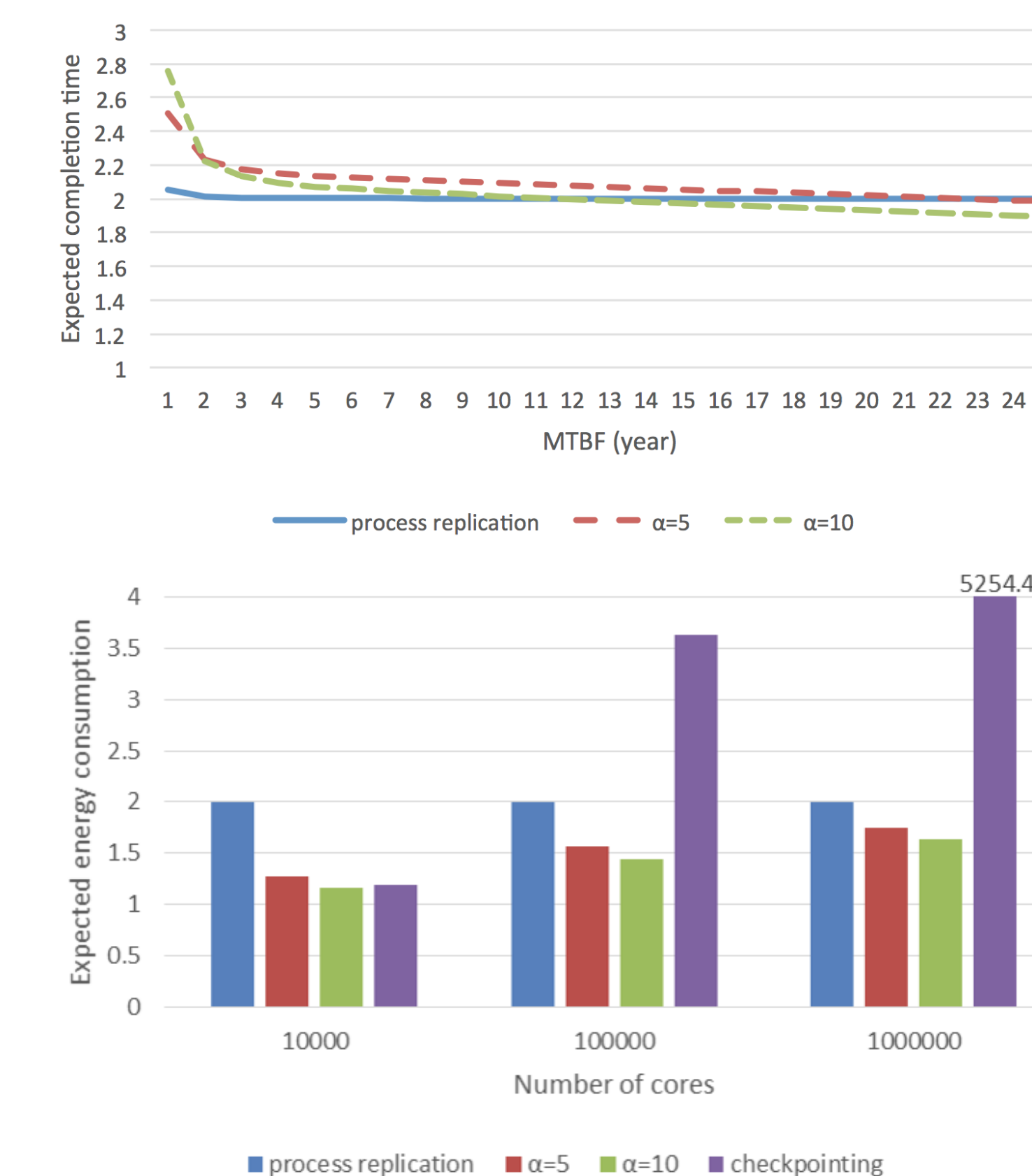
Main process successful completion



Main process failure

## EVALUATION

Compared to existing fault tolerance methods, Lazy Shadowing can achieve 20% energy saving with reduced solution time at scale.



## FUTURE WORK

There are two directions:

1. Build a simulator to validate the model
2. Implement a prototype for Lazy Shadowing and evaluate the performance

## CONCLUSION

Understanding the interplay between fault-tolerance and energy consumption is critical for the viability of future large scale systems. To this end, we propose Lazy Shadowing as a scalable, energy-aware fault-tolerance approach. The

beauty of Lazy Shadowing is its ability to explore a parameterized tradeoff between hardware and time redundancy to tolerate failures and balance between response time and energy consumption.

## ACKNOWLEDGMENT

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