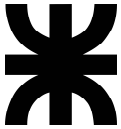
Parallel Evolutionary-Statistical System for applying in Forest Fire Spread Prediction

Germán Bianchini
Miguel Méndez-Garabetti
Paola Caymes-Scutari



LICPaD
Laboratorio de Investigación en Cómputo Paralelo/Distribuido
DISI - UTN - Facultad Regional Mendoza

Organization

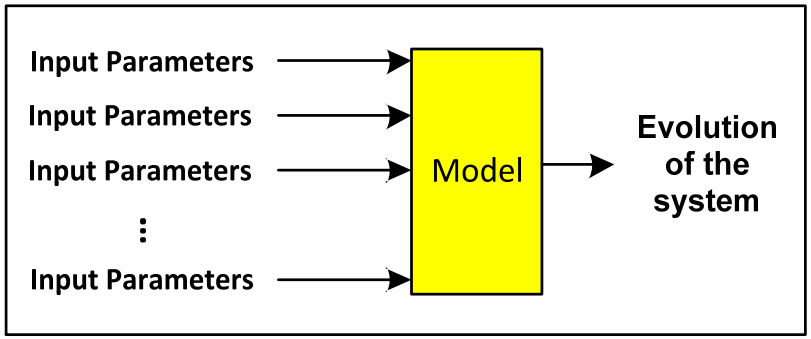
- Introduction
- Classical prediction
- Evolutionary Statistical System
- Experimental results
- Conclusions
- Future work

Organization

- Introduction
- Classical prediction
- Evolutionary Statistical System
- Experimental results
- Conclusions
- Future work

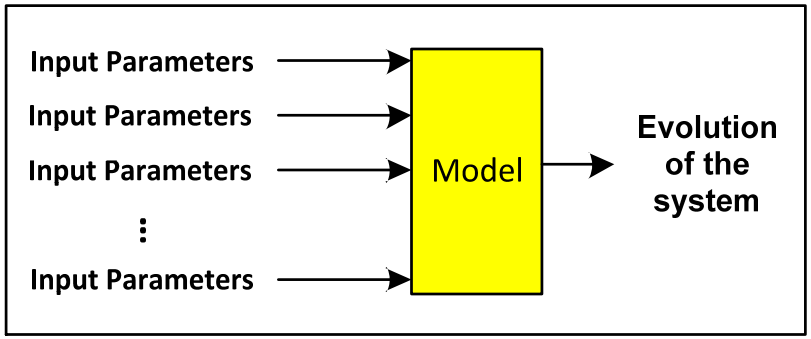
Introduction (i)

- Use of models in several scientific areas.
- These models receive some input parameters representing some particular conditions and they provide an output representing the evolution of the system.
- A particular case where models are very useful is the prediction of Forest Fire propagation.



Introduction (ii)

- However, in many cases the models present a series of limitations.
- Such restrictions are due to the need for a large number of input parameters and, usually, such parameters present some uncertainty.
- In consequence, they have to be estimated from indirect measurements.

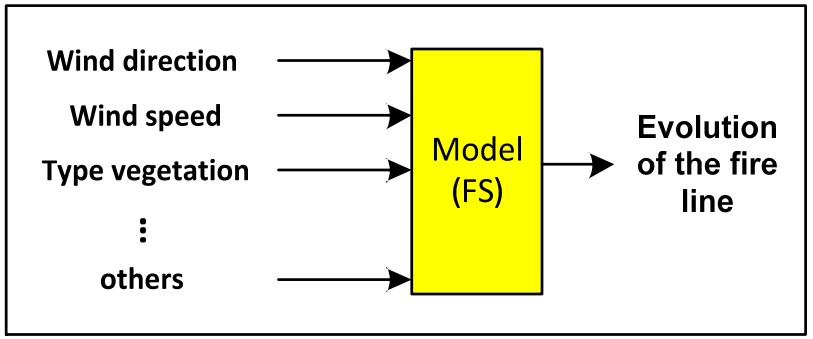


Organization

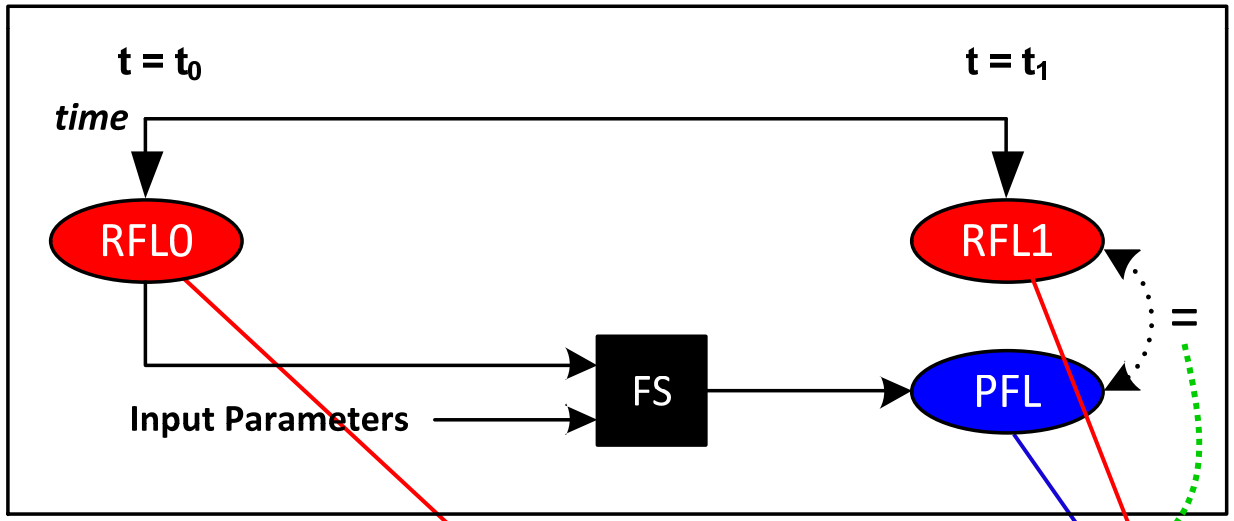
- Introduction
- Classical prediction
- Evolutionary Statistical System
- Experimental results
- Conclusions
- Future work

Clasical Prediction (i)

- The simulator is fed the required parameters (vegetation, meteorological conditions, etc.) and then executed to predict the fire line after a certain period of time.
- The simulator cannot be run in the absence of one of these input parameters.
- The resulting prediction is based on a single simulation.



Clasical Prediction (ii)



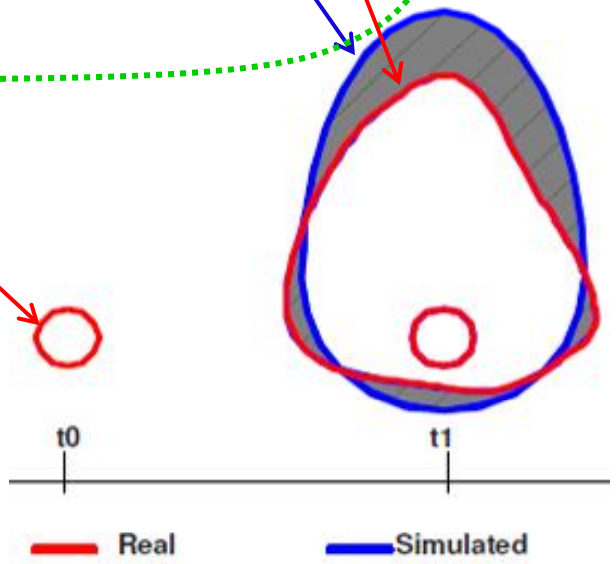
RFL0: Real Fire Line, t0

RFL1: Real Fire Line, t1

PFL: Predicted Fire Line

FS: Fire Simulator

$$PFL \not\equiv RFL1$$

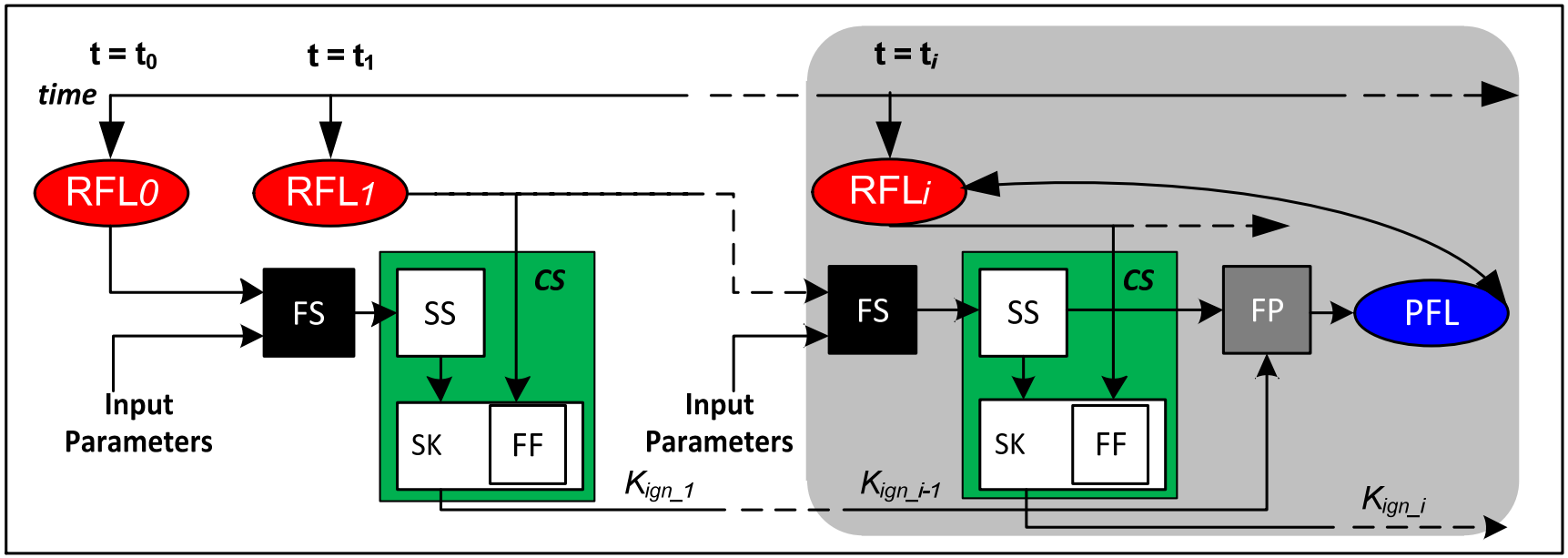


Organization

- Introduction
- Classical prediction
- Evolutionary Statistical System
- Experimental results
- Conclusions
- Future work

Statistical System for Forest Fire Management (i)

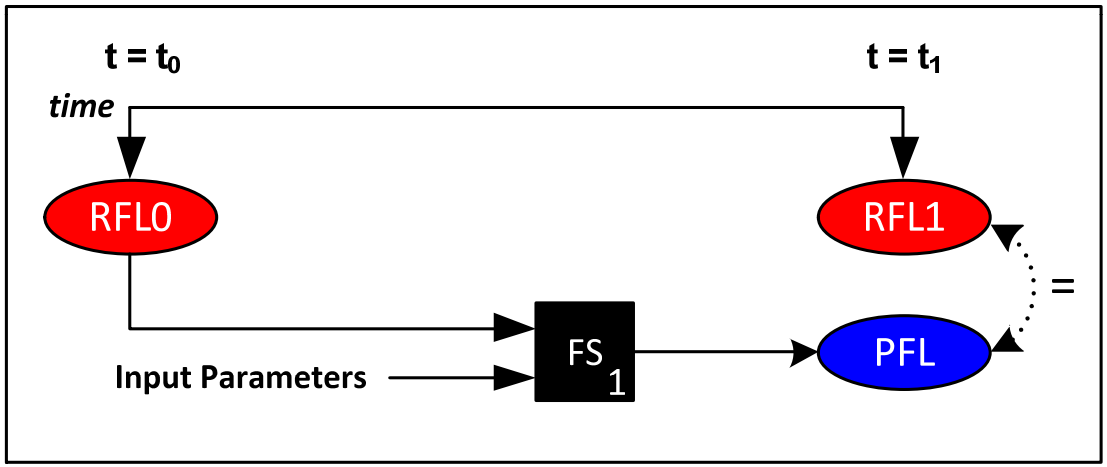
S²F²M: Statistical Analysis + Distributed Computing

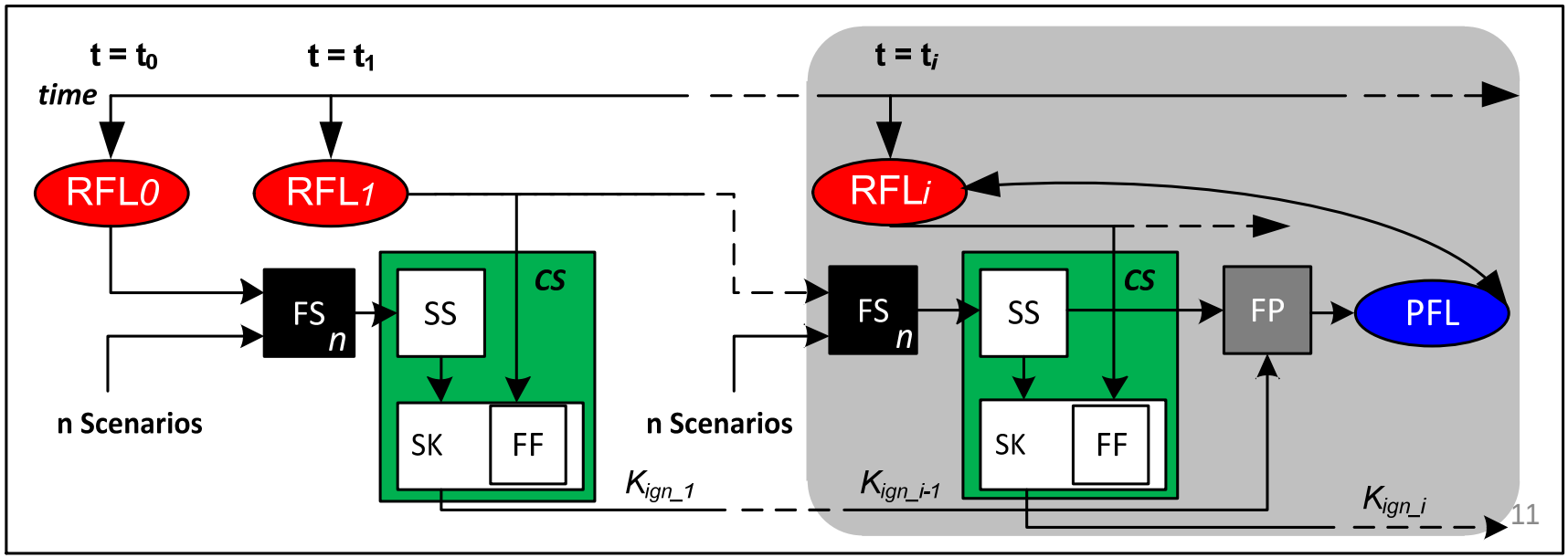


- FF: Fitness Function
- CS: Calibration Stage
- FP: Fire Prediction
- SK: Search *Kign*
- FF: Fitness Function
- PFL: Predicted Fire Line
- RFLi: Real Fire Line on time i
- FS: Fire Simulator
- SS: Statistical Stage

Statistical System for Forest Fire Management (ii)

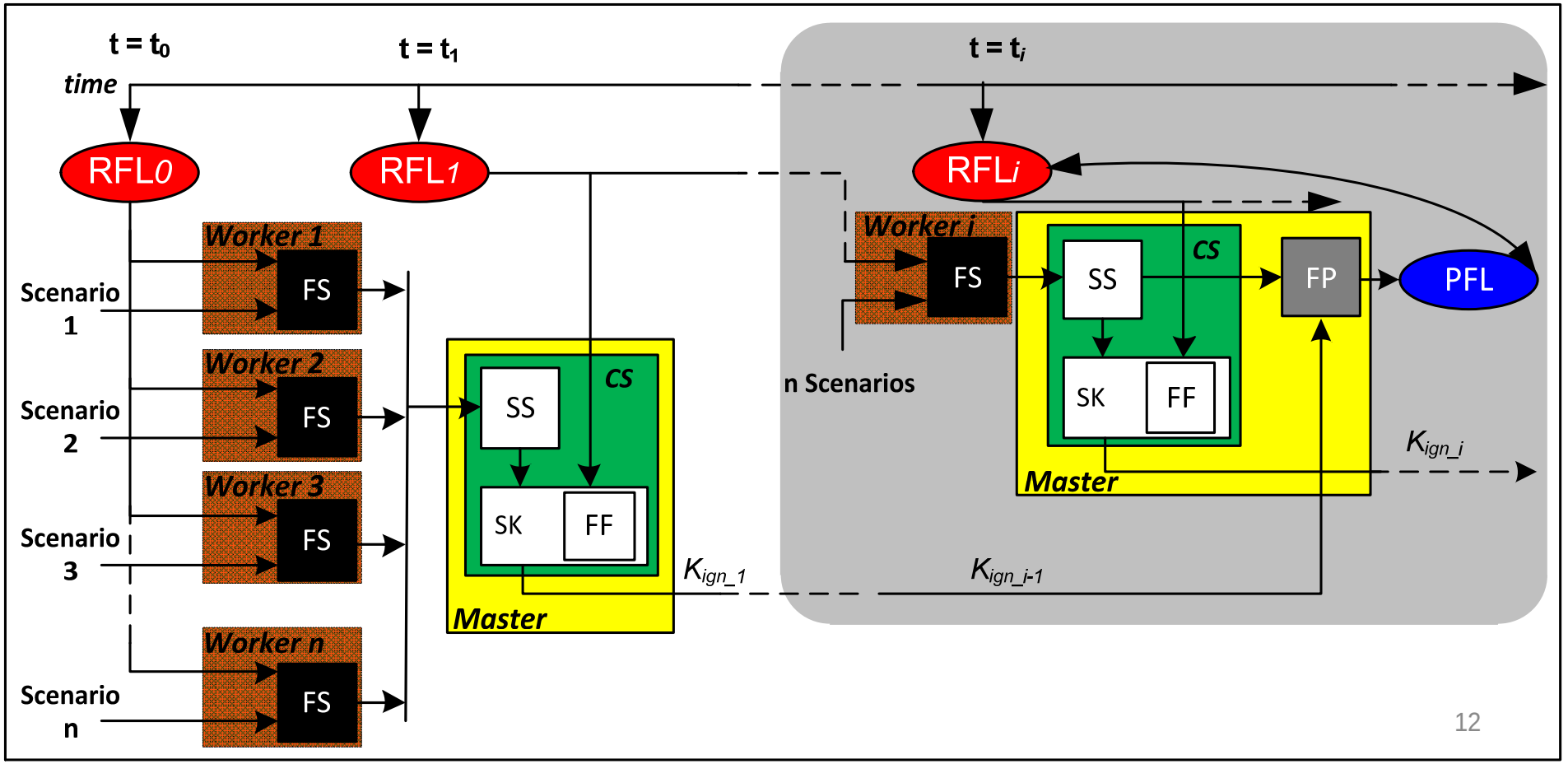
Comparison:





Statistical System for Forest Fire Management (iii)

Parallelizing S^2F^2M:



Evolutionary Statistical System (i)

- ESS combines the original uncertainty reduction method implemented in S^2F^2M with the advantages that offer the PEAs.
- ESS is based on statistics, mainly on the concept of factorial experiment, where the combination of several factors (input parameters) defines an individual (scenario).

Evolutionary Statistical System (ii)

ESS: **Uncertainty Reduction + Parallelism + Evolutionary Algorithm**

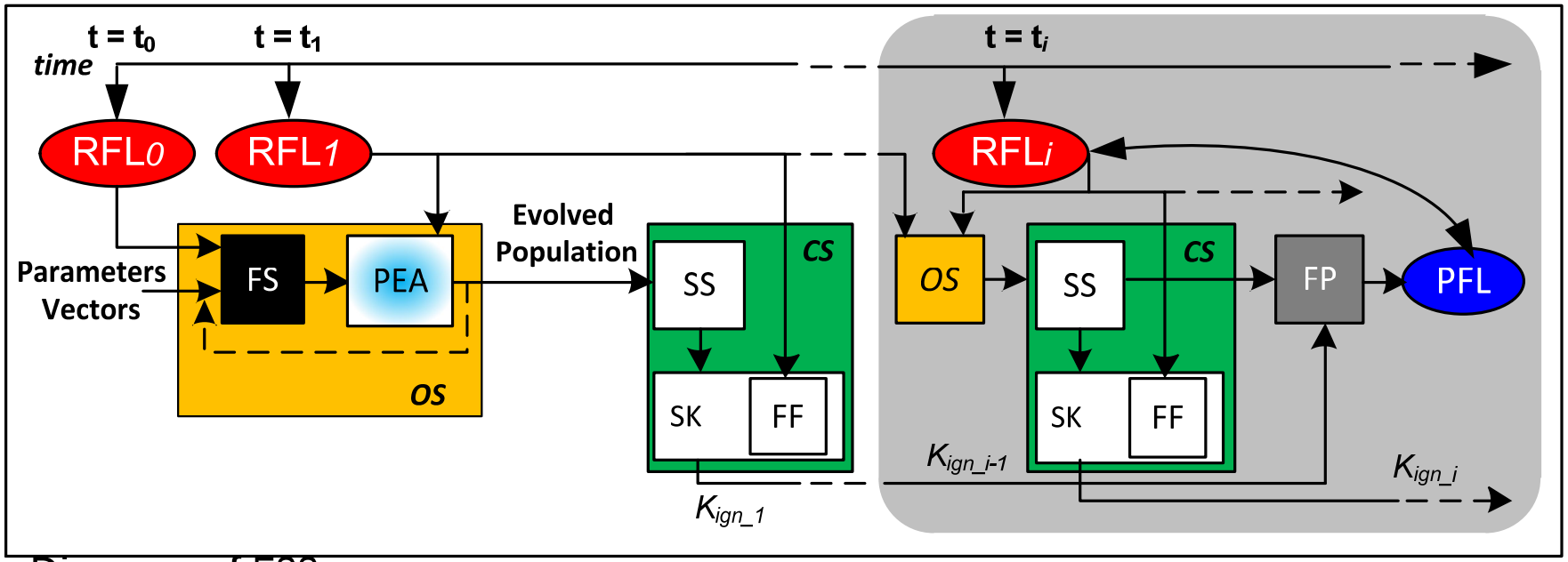


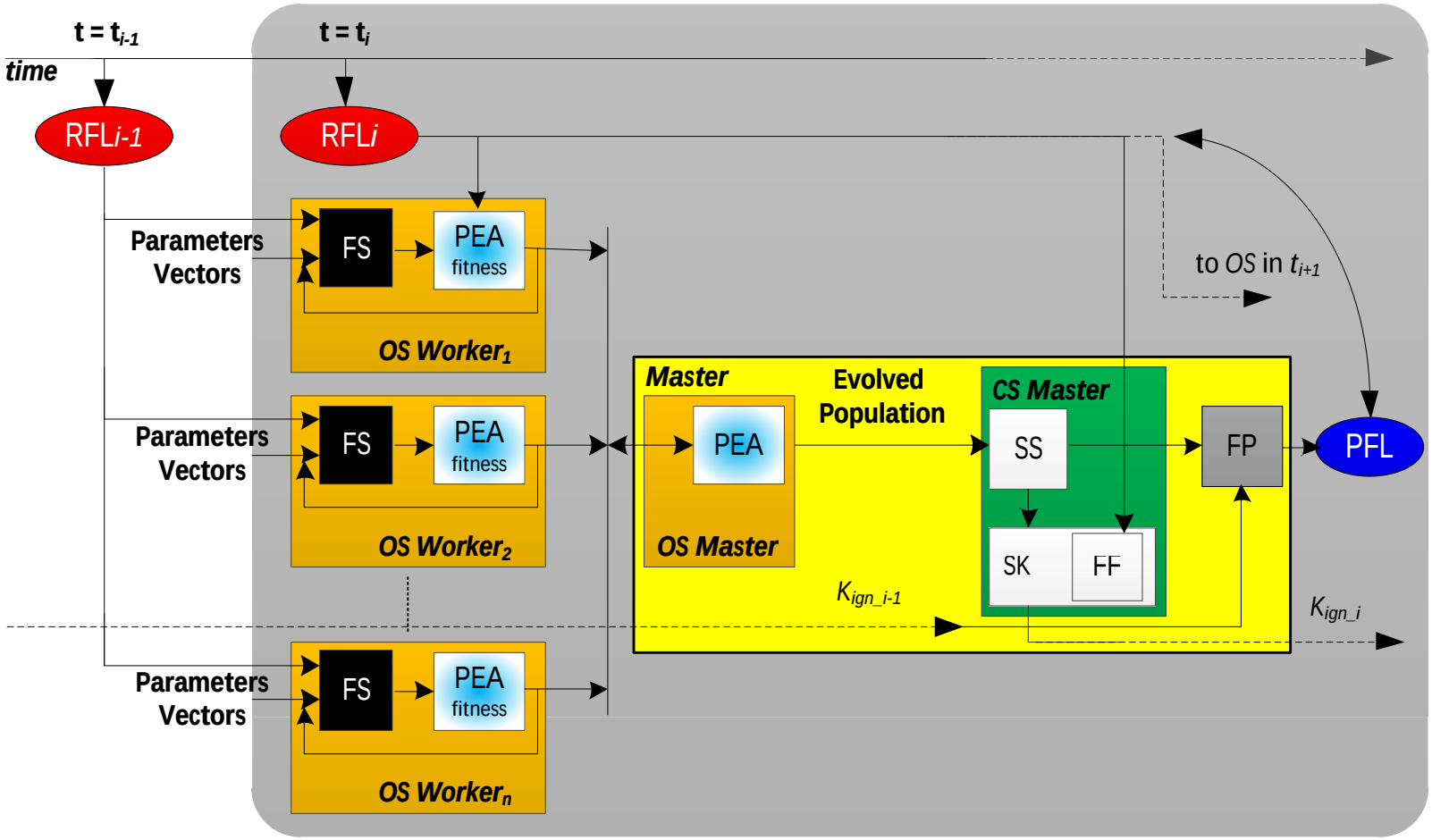
Diagram of ESS

- PEA: Parallel Evolutionary Algorithm
- OS: Optimization Stage

The improvement of the method is related to the introduction of features of PEAs in the calibration step of the statistical method.

Evolutionary Statistical System (iii)

Parallelizing ESS: Unique Population and Parallel Evaluation



Organization

- Introduction
- Classical prediction
- Evolutionary Statistical System
- Experimental results
- Conclusions
- Future work

Experimental Results (i)

- Four experiments
  - Serra da Lousã (Gestosa, Portugal)
  - SPREAD Project

Experiment	Width (m)	Length (m)	Slope (°)
1	58	50	21
2	89	91	21
3	95	123	21
4	20	30	6

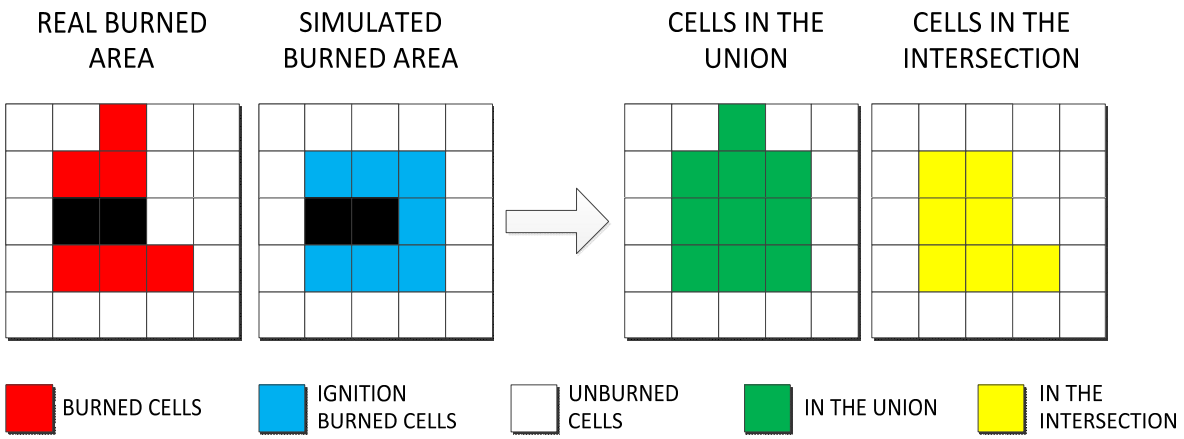
Experimental Results (ii)

– Fitness function

- To evaluate and compare the systems' responses, we defined a fitness function.

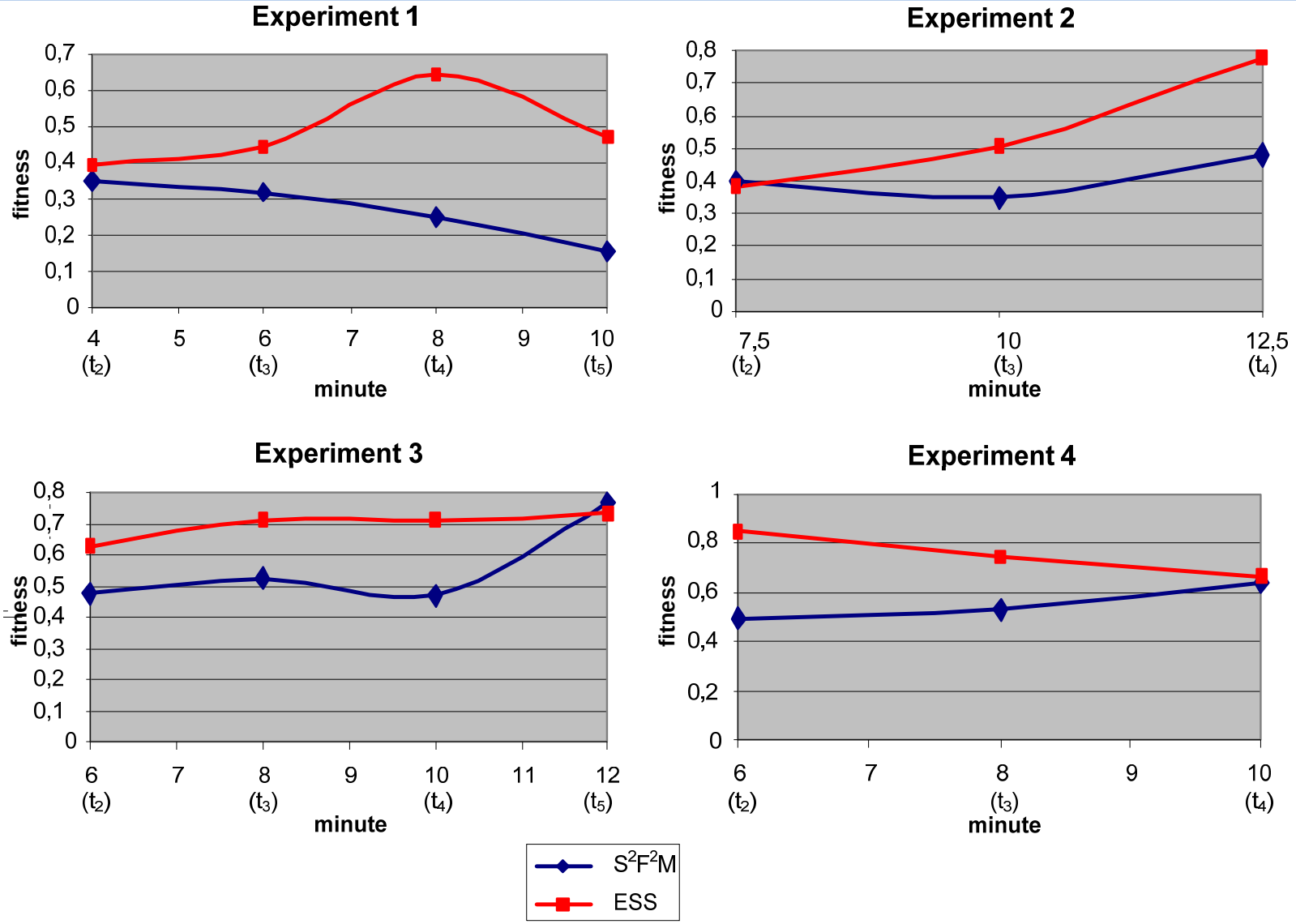
$$Fitness = \frac{\#cells \bigcap - \#IgnitionCells}{\#cells \bigcup - \#IgnitionCells}$$

- Example:

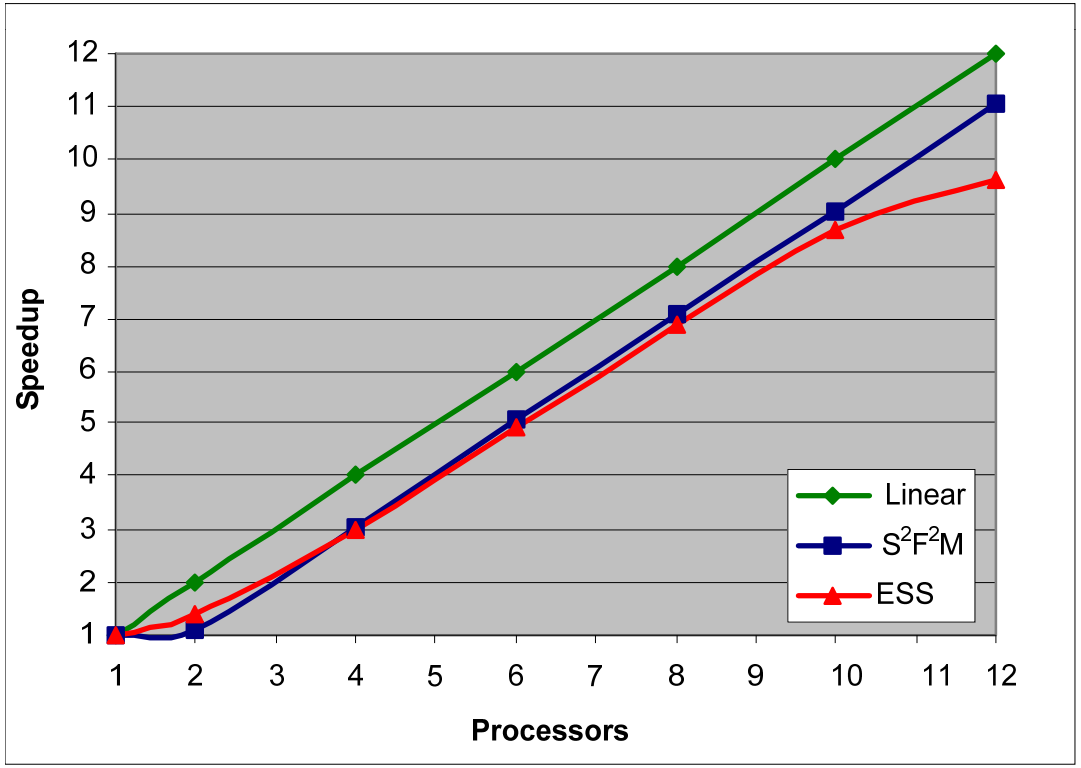


$$Fitness = \left(\frac{\#cell \bigcap - \#IgnitionCells}{\#cell \bigcup - \#IgnitionCells}\right) = \left(\frac{7-2}{10-2}\right) = 0.625$$

Experimental Results (iii)



Experimental Results (iv)



- Regarding execution time, ESS spends 10% less than the time of the original method in average.
- However, according to the problem, the time may be lower even.

Organization

- Introduction
- Classical prediction
- Evolutionary Statistical System
- Experimental results
- Conclusions
- Future work

Conclusions

- ESS provides a significant improvement compared with the previous methodology.
- ESS is general enough to be used on different models as floods, avalanches, etc.
- ESS combines statistics and parallel evolutionary algorithms.
- The combination of evolutionary computation, parallelism and uncertainty reduction is a promising option for tackling various Grand Challenge Problems.

Organization

- Introduction
- Classical prediction
- Evolutionary Statistical System
- Experimental results
- Conclusions
- Future work

Future work

- In this first approach of ESS, we decide apply parallelism only in the evaluation of the individuals.
- The goal of gradually increase the degree of parallelism to compare the results offered by each alternative of PEAs.
- Further study should focus on the analysis and tuning of the method to obtain the best possible results and compare it with other methods.

Muchas gracias por su atención…

LICPaD
Laboratorio de Investigación en Cómputo Paralelo/Distribuido
DISI - UTN - Facultad Regional Mendoza