3rd National Workshop for High Performance Comuting Scientific Applications
WHPC2014

SENSOR CLOUDS

A precision agriculture application

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Outline

Motivation

Frost Defense

WSN on Cloud

Frost Prediction Application

Experiments

Conclusions

Motivation

Province of Mendoza (Argentina)

- •160,704 ha of vineyards
- •70.31% of national production
- • 730 millions of u$s dollars

Frosts

- •Temperature falls below 0ºC under 1.5 meters
- •Even below 3ºC depending depending the stage
- •Two phase damage: cellular burst and dehydration
- •Damage 5% to 15% of World agricultural production (Mendoza: 9%)
- •September 2013: many districts of Mendoza lost up to 80% of crops

Frost damages




Domingo, 06 de octubre de 2013

Por las heladas, año negro para la fruta y la uva

Se esperan 18 meses de crisis en las zonas afectadas, hasta la próxima temporada. Prevén fuerte caída del empleo rural y precios más caros.

PANORAMA. SE ACONSEJA QUE LOS PRODUCTORES CUYOS CULTIVOS HAYAN RESULTADO DAÑADOS, DECLAREN ESA SITUACIÓN.

Por Gustavo Flores Bazán
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Aunque aún no hay cifras definitivas de los daños que han ocasionado las heladas de los últimos días de setiembre sobre los cultivos de Mendoza, de acuerdo con el panorama trazado por los propios afectados han sido las más severas de los últimos 20 años. Desde 1991 –al menos en la zona Sur– no se recuerda desastre similar al ocurrido en los últimos días.

FROST DEFENSE

Passive defense

- •Choose zone and species wisely
- •Not always possible

Active defense

- •Detect/predict frost and apply countermeasures
- •Most used: kerosene/diesel heaters and water sprinklers
- •Other: fans/turbines, helicopters (expensive), greenhouses (small areas), smokescreens (no wind), infrared heaters (bad results)

Detection/Prediction

- •April to October
- •Need of a wide and cheap weather sensor network
- •Need of an on-demand computing infrastructure (HPC/HTC)

Calorías aportadas por distintos combustibles

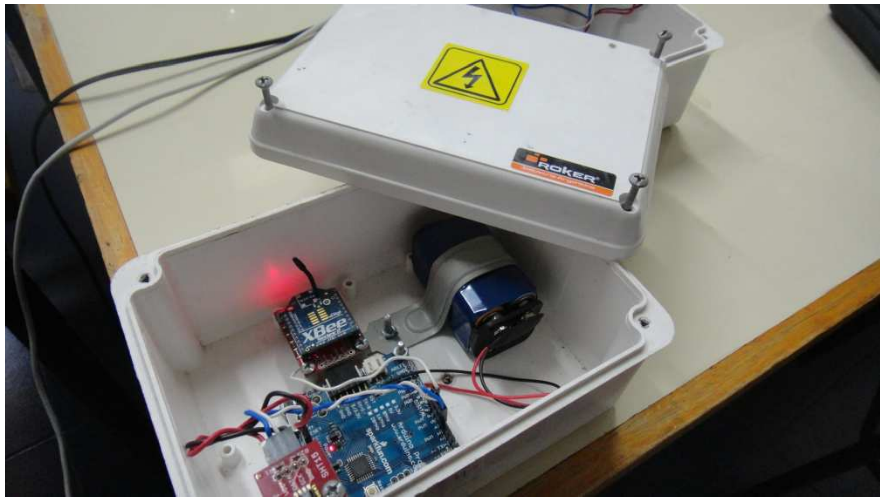
Madera	3.990 - 4.420	Kcal por Kg
Carbón Vegetal	8.080 - 8.100	Kcal por Kg
Carbón Mineral	3.335 - 8.115	Kcal por Kg
Fuel oil	10.454	Kcal por Kg
Gas oil	entre 10.188 y 10.852	Kcal por Kg
Kerosén	10.995	Kcal por Kg
Petróleo crudo	10.496	Kcal por Kg
Biodiesel	entre 10.094 y 10.732	Kcal por Kg

WSNs

Weather Sensor Networks
- Universidad Nacional de Cuyo & Universidad de Mendoza

Node characteristics:
- humidity and temperature
- low power consumption
- low cost
- robustness
- reliability

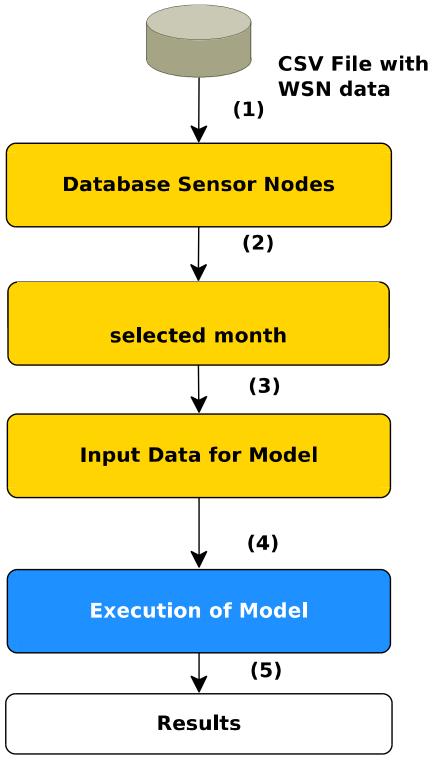
Interconnection
- ZigBee (node to base station)
  - Based on IEEE 802.15
  - 250 kbit/s
- TCP/IP (uplink from base station)
  - Required bandwidth: 64 bytes/s
  - Process generates delay of 0,5 s



Lucas Iacono, Carlos García Garino, Osvaldo Marianetti and Cristina Párraga, *Wireless Sensor Networks: A Software as a Service Approach*. **HPCLatAm 2013**. Mendoza, Argentina.
José Luis Vazquez Poletti, Clouds for Meteorology, two cases study. HPC Workshop, Cetraro, Italy, July 7-11, 2014.

Frost prediction application

- Allows to predict **radiation (hoar) frost**
- Calculates minimum temperature in nights without clouds and cold fronts
  - with and without dew point
- Continuous comparison with historical data
  - temperature 2 hours after sunset
  - minimum temperature during previous night
  - dew point (if chosen, needs humidity sensor)



Sensor Cirrus
Wireless Sensor Cloud Platform

https://sites.google.com/site/sensorcirrus/

R. L. Snyder, J. P. Melo-Abreu, *Frost protection: Fundamentals, Practice and Economics*, Vol. 1, **Food and Agriculture Organization of the United Nations (FAO)**, 2005.

EC2 CLOUD Processing

WSN Initial problems:

1. Need to process large volume of data on technologies not prepared to scale
2. Users must have knowledge of WSN programming
3. Scaling is not economically feasible
4. No fault tolerance and high reliability mechanisms (data process)

Solutions:

1. On-demand provided resources
2. Process delegated to 3rd party applications running on 3rd party infrastructure
3. Pay-as-you-go infrastructure
4. Infrastructure with SLA and on-demand deployment of additional resources

Test Scenario	Instance	vCPUs	ECU	Memory (GBytes)	Cost on demand (U$S)
I	t1.micro	1	variable	0.615	0.020
II	m1.small	1	1	1.7	0.047
III	m1.large	2	4	7.5	0.190
IV	m1.xlarge	4	8	15	0.379
V	c3.xlarge	4	14	7.5	0.239

EC2 Cloud Processing

Experiments

- execution of frost prediction application
- 4 experiments with different number of sensor nodes (10-1000) for each instance (1 node = 1 task)
- usage cost from average execution time and Amazon EC2 pricing

Test Scenario	Instance	vCPUs	ECU	Memory (GBytes)	Cost on demand (U$S)
I	t1.micro	1	variable	0.615	0.020
II	m1.small	1	1	1.7	0.047
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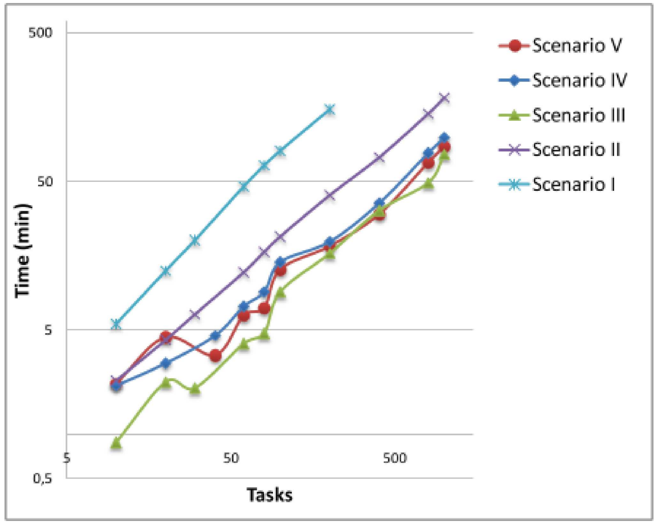

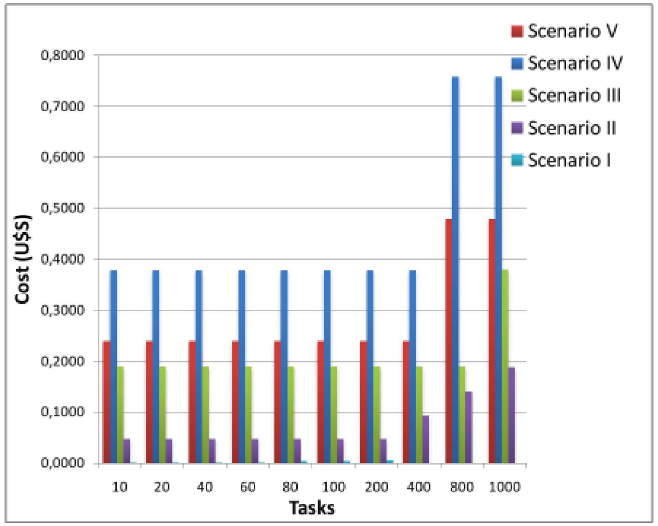

Performance Model

Test Scenario	Instance	vCPUs	ECU	Memory (GBytes)	Cost on demand (U$S)
I	t1.micro	1	variable	0.615	0.020
II	m1.small	1	1	1.7	0.047
III	m1.large	2	4	7.5	0.190
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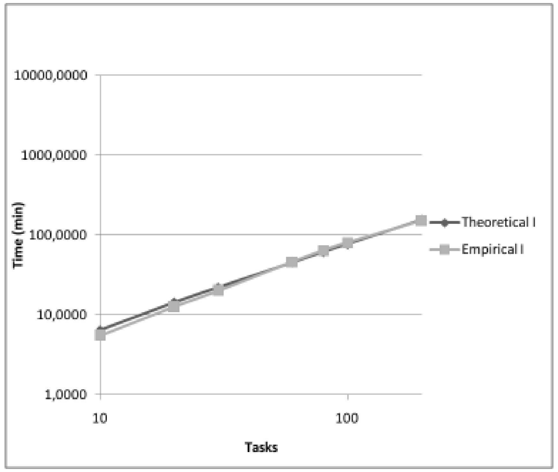
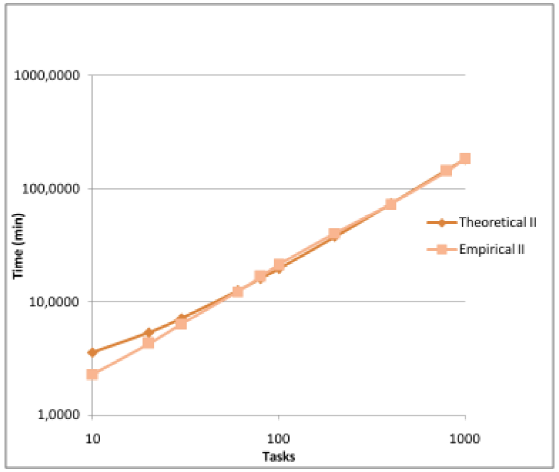


(a) Scenario I.

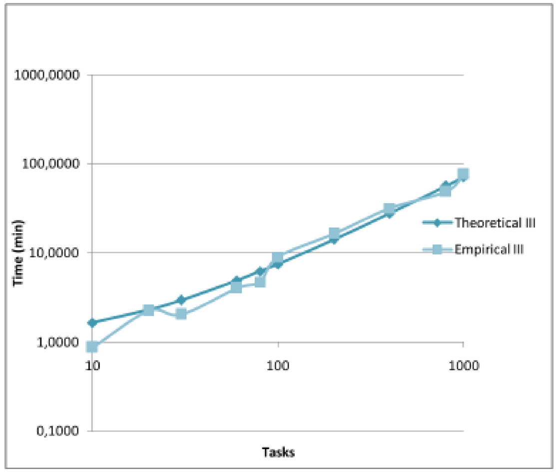


(b) Scenario II.

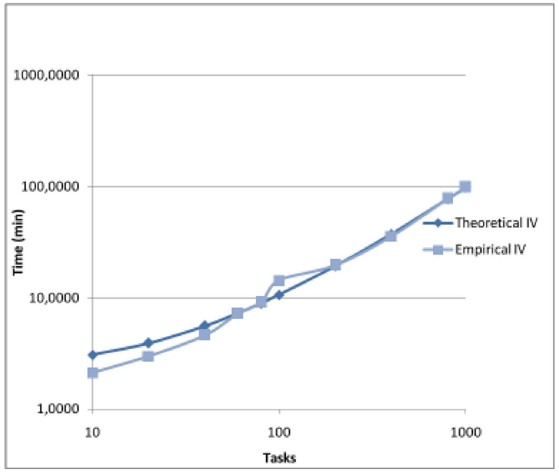
$$t = Ax^2 + Bx + C$$

Table 2: Coefficients of Each Scenario Theoretical Model.

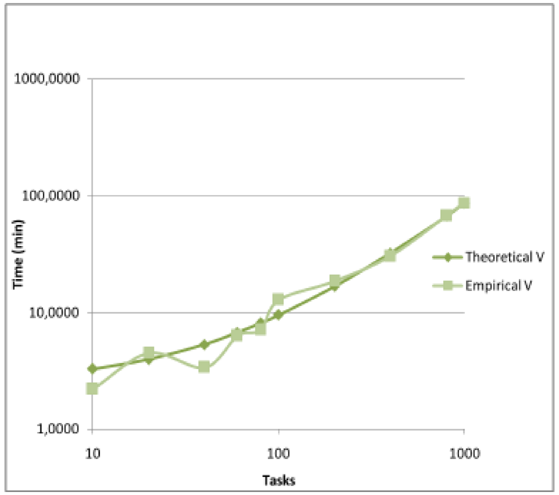
Scenario	A	B	C
I	0	$7.8526E-01$	-1.4436
II	$1.8465E-06$	$1.7883E-01$	1.8027
III	$6.0225E-06$	$6.5069E-02$	$9.9827E-01$
IV	$1.4014E-05$	$8.2443E-02$	2.2512
V	$1.6670E-05$	$6.7349E-02$	2.5970



(c) Scenario III.



(d) Scenario IV.



(e) Scenario V.

Execution model (small example)

- Optimal number of nodes per instance (by means of performance)
- Deadline: 1 hour

Test Scenario	Instance	Nodes	Execution Time (min)	Economic Cost (U$S)
I	t1.micro	78	59.806	0.020
II	m1.small	324	59.937	0.047
III	m1.large	841	59.980	0.190
IV	m1.xlarge	632	59.952	0.379
V	c3.xlarge	722	59.912	0.239

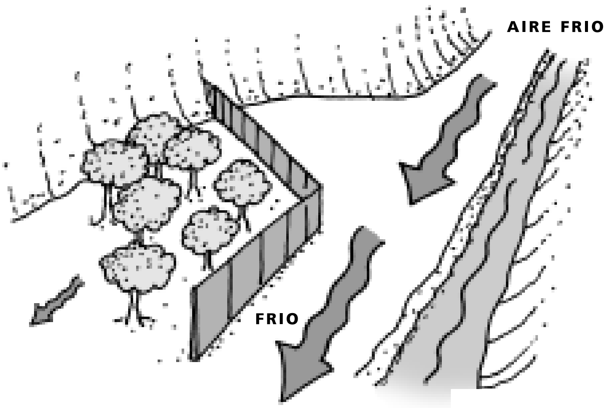
Remind: 160,704 ha of vineyards!

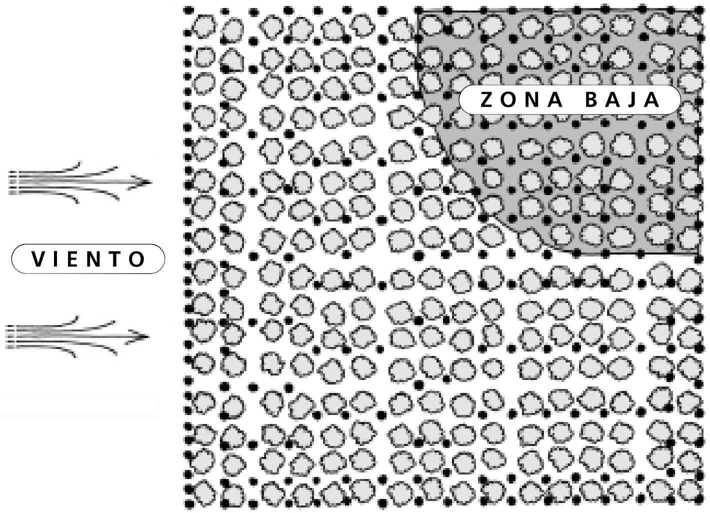
Short term improvements

- Model considering multiple instances
  - Performance, cost and cost/performance
- Placement based on WSN resolution
  - 100 nodes/ha, 10 nodes/ha…
- Placement to cover different fields and share costs

Mid-long term tasks

- Placement strategy to cover different fields and share costs
- Transfer optimization
- Optimal node deployment considering environmental elements (PICT)





Concludings Remarks

- Application focused to solve a production problem
- Can be easily replicated in other provinces
- The model can be enriched considering environmental elements
- Larger numbers of nodes can be taken into account
- In general more computational power will be required
- Restrictions: time processing 1 hour maximum! Scheduled processing time is fixed