A Ubiquitous Urgent Computing Framework for Ensembles of Flash Flood Forecasts

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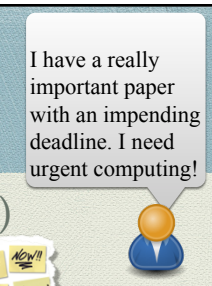
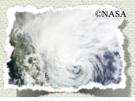
Urgent Computing



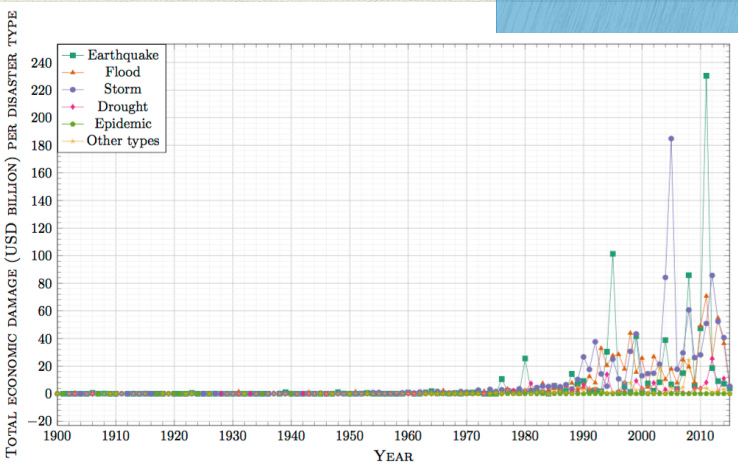
- Requires computations (**disasters**)
  - ✓ – Commence in short order
  - ✓ – Complete before a stipulated **deadline**
  - ✗ – Support mitigation activities
  - ✗ – From events that requires immediate attention



[8] S. H. Leong and D. Kranzlmüller. Towards a General Definition of Urgent Computing. In *ICCS Proceedings*, volume 51 of *Procedia Computer Science*, pages 2337 – 2346. Elsevier, 2015.

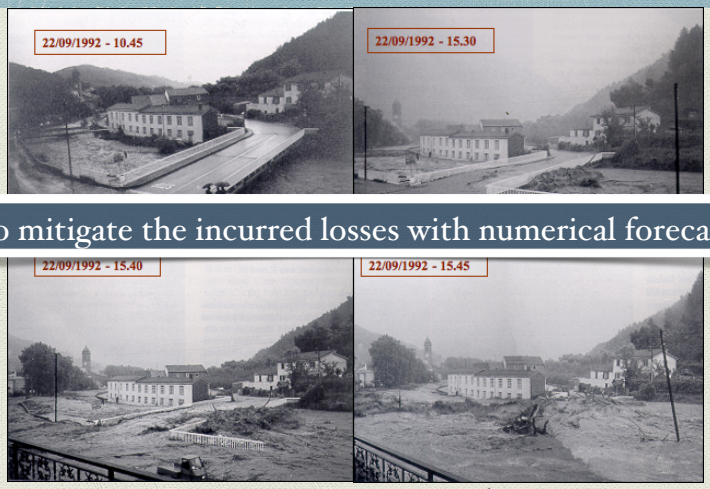
Motivation

EC Joint Research Centre
- Germany's flooding in 2080
  - 170,000 - 323,700 affected population
  - 5.3 - 33.9 billion EUR



(b) Total Economic Damage caused by Reported Natural Disasters (EM-DAT)

Motivation



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To mitigate the incurred losses with numerical forecasts

Sudden Flash Flood in a small catchment (Mediterranean area)

Problems & Proposed Solutions

Inaccuracy in observational data

Limitations of forecast models

Coordinate Multiple Forecasts under Timing Constraints in a Chaotic Environment

Ubiquitous Framework with Resource Allocation Heuristic

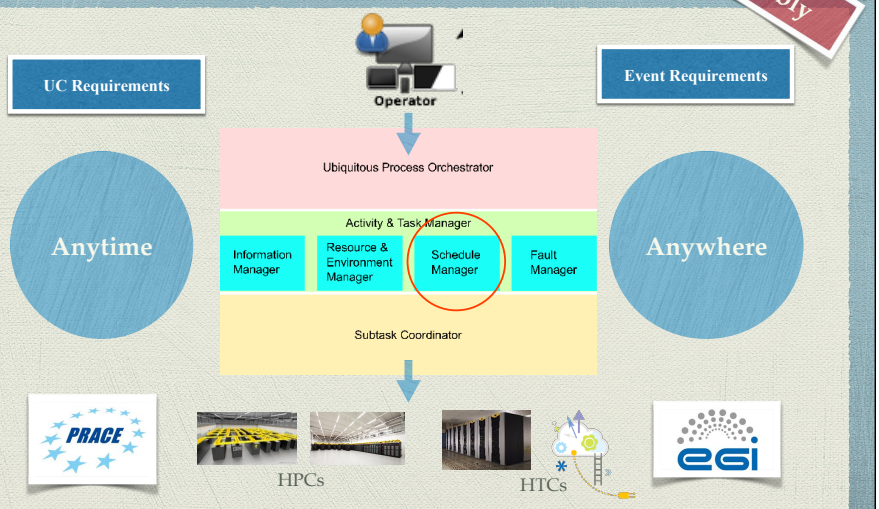
Leverage on zero hour data

Stochastic forecast methods

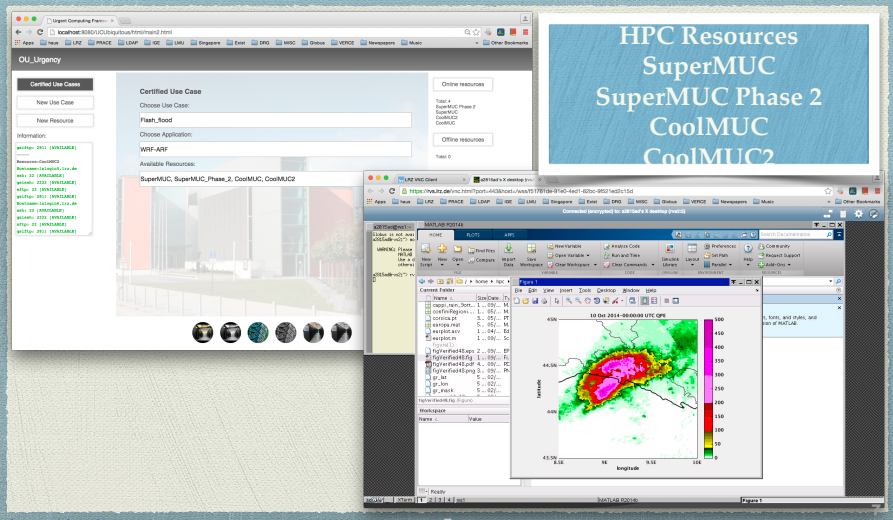
Task-based Ubiquitous (TbU) Approach

Swiftly

Reliably



TbU Approach



Resource Allocation Heuristic Objectives

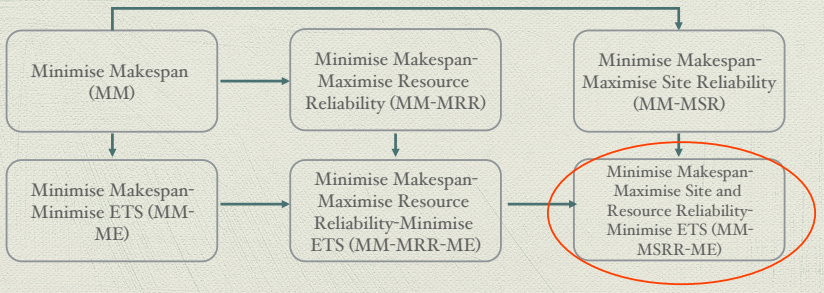
Meeting the stipulated deadline

(i) Maximise Makespan Robustness
(ii) Minimise Energy Usage
(iii)Maximise Reliability across Sites and/or Resources

Reliability across resources and/or sites → Maximise Reliability

Resource Allocation Heuristics

Priority 1:	Maximise Makespan Robustness /Minimise Makespan
Priority 2:	Maximise Site and/or Resource Reliability
Priority 3:	Minimise Energy-To-Solution

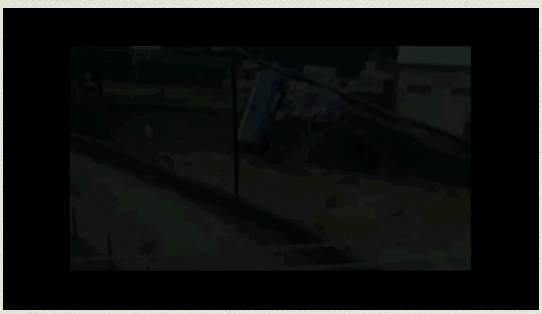


Genoa flash flood October 2014

Flash flood: one of the the most dangerous type of floods as it can form swiftly with little or no prior warning.

- Forecast heavy rain and storm
- No warning about flood

- Two rivers overflow the banks
- More than one metre of water and mud
- Electricity cut, school closed, train derailed

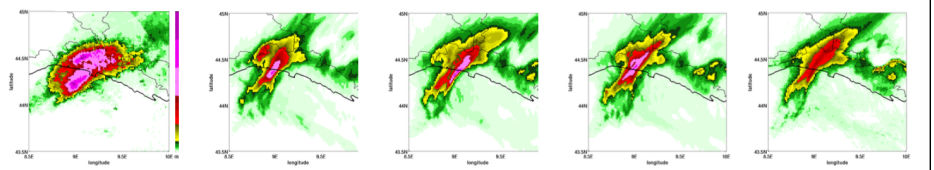


Test & Results

- Case Study
  - Forecast Genoa flash Flood (9 Oct. 2014)
  - Loss: ~303 million USD and one death (EM-DAT)
  - Deadline: 3 hours
- WRF-ARF Model
  - Eight ensemble forecasts with different microphysics options
  - Each forecast: 640 cores to generate a 24 hours forecast with 2 domains (5km and 1 km)

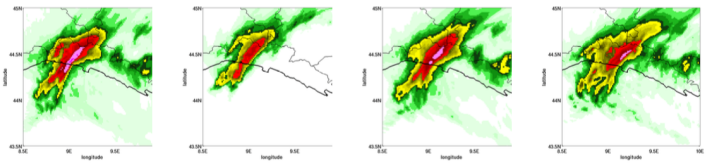
Resource	Available cores	Default Freq (GHz)	Freq Scaling	Site	Availability	Performance	ETS
SuperMUC	131,072	2.3	yes	LRZ	0.85	High	Medium
SuperMUC Phase 2	71,680	2.2	yes	LRZ	0.85	High	Low

Test & Results



(a) Radar Verification (b) Kessler (c) WSM3 (d) WSM5 (e) Ferrier

At the 24th hour

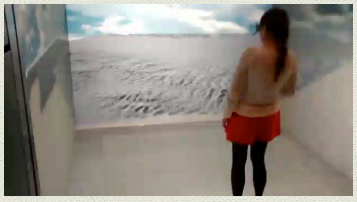


(f) WSM6 (g) WSM6D (h) Thompson (i) Morrison

Conclusion

- TbU approach
  - 3-layer architecture
  - Ubiquitous access from anywhere and at anytime
  - Realise urgent computing and event requirements
- Resource Allocation Heuristic
  - Manage resource allocation swiftly
  - Fulfil three objectives
    - Minimise Makespan-Maximise Site and Resource Reliability-Minimise ETS

Future Work

- Cost of Urgent Computing
  - Preemption
- Prediction Models
- Advanced Visualisation

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