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SAND2004-1548

# Completing the Journey of Moore's Law

**SOS8**

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**Sandia National Laboratories**



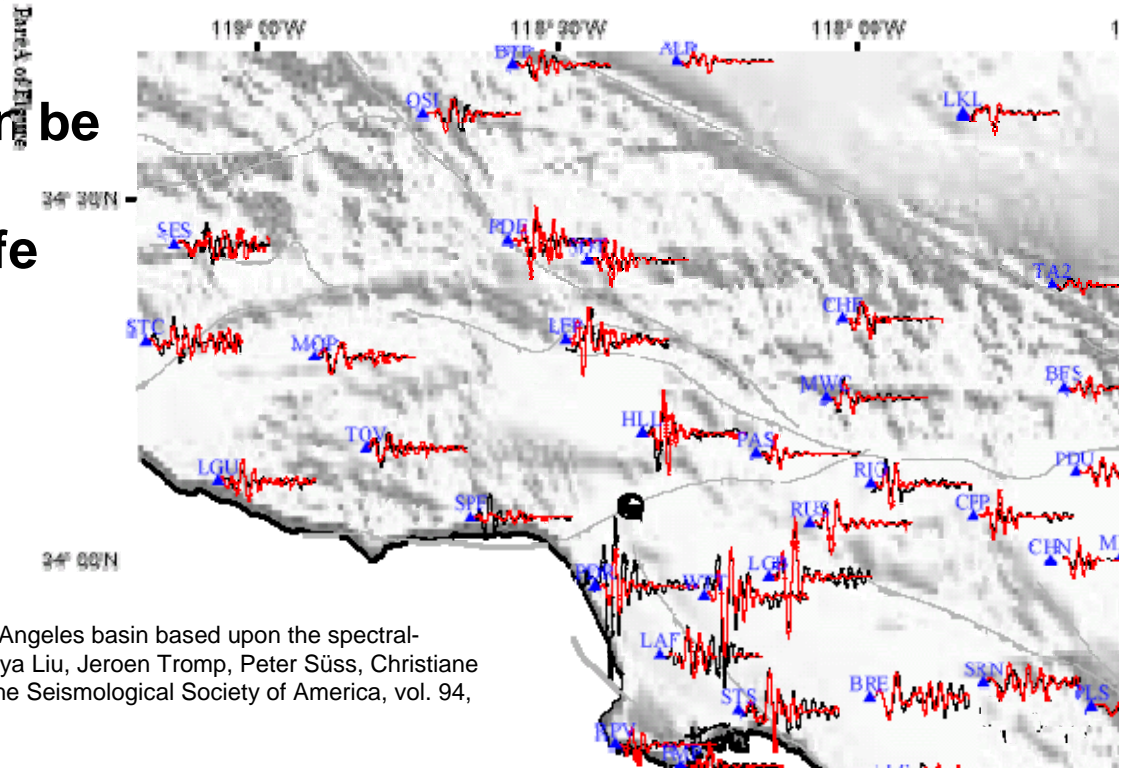
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# Example Application: Earthquake Mitigation

- Simulation of ground motion due to earthquakes can be useful in deciding where it is safe to build structures
- Until available data can be analyzed, there will be unnecessary loss of life and property
- Required compute power for sufficient analysis of existing data: 1 Exaflops



Simulations of ground motion in the Los Angeles basin based upon the spectral-element method, Dimitri Komatitsch, Qinya Liu, Jeroen Tromp, Peter Süss, Christiane Stidham and John H. Shaw, Bulletin of the Seismological Society of America, vol. 94, number 1, in press (2004)



# Earthquake Risk Mitigation

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- **Algorithms: Written**
- **Code: Runs**
- **Input Data: Exists**
- **Consequence of Not Proceeding: People Die**
- **Required FLOPS:  $1E = 1000P = 1,000,000T$** 
  - **25,000 × Earth Simulator**



# Limits for a Red Storm-Sized Computer

Best-Case Logic		Microprocessor Architecture	Physical Factor	Source of Authority
2.5×10 <sup>26</sup> ops/s			Landauer limit 500KW/(k <sub>B</sub> T log <sub>e</sub> 2)	Esteemed physicists
			Derate 20,000 convert logic ops to floating point	Properties of double precision floating point
12.5 Zetaflops			Derate limit 150 to achieve e <sup>-100</sup> error rate	Current logic circuit properties
Expert Opinion	100 Exaflops	800 Petaflops	Derate for manufacturing margin (4×)	Estimate
Estimate	25 Exaflops	200 Petaflops	Uncertainty (6×)	Gap in chart
	4 Exaflops	32 Petaflops	Improved devices (4×)	Estimate
	1 Exaflops	8 Petaflops	Projected ITRS improvement to 22 nm (100×)	ITRS committee of experts
		80 Teraflops	Lower supply voltage (2×)	ITRS committee of experts
		40 Teraflops	Red Storm	contract

Assumption: Supercomputer consumes 2 MW wall power = 500 KW to chips
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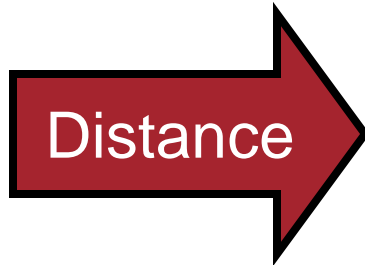
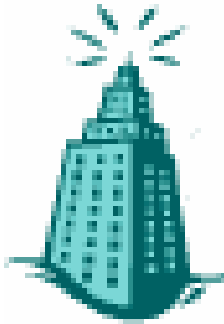
## Conclusions

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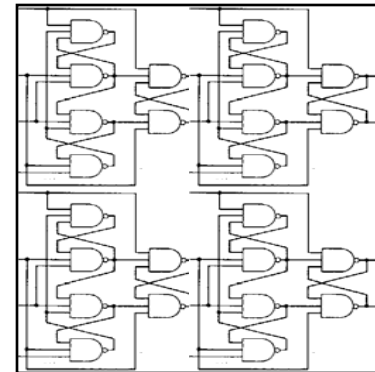
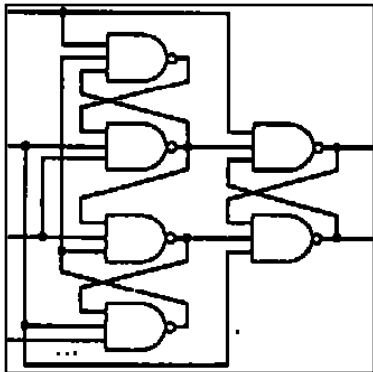
- **When we look into the future of supercomputing**
  - We see some haze
  - However, the end of the road is becoming visible through the haze
- **Knowing the end of the road helps now**
  - What applications should we anticipate solving?
  - Some software written today will run on end-of-road supercomputers. What architectures will/will not be around?
- **Other roads follow**



# FM Radio and End of Moore's Law



Driving away from FM transmitter → less signal  
Noise from electrons → no change



Increasing numbers of gates → less signal power  
Noise from electrons → no change





# Potentials of Supercomputing

