Calculation of Surface Acoustic Waves on a Piezoelectric Substrate using Amazon™ Cloud Computing

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Introduction:

We present benchmark comparisons between a local desktop workstation (PC) vs. Amazon Web Services™ (AWS) for the complex calculations of Surface Acoustic Waves (SAW) on a piezoelectric substrate in 3D.

Computational settings:

- Comsol Multiphysics® 5.1
- Time dependent ($\Delta t \approx 6$ ns) iterative multigrid solver (GMRES) over 5 cycles
- RAM optimized AWS machine (EC2 r3.8xlarge)
- Model: 5851188 degrees of freedom

Table 1. Comparison: Workstation vs. AWS

	Workstation	**AWS** "r3.8xlarge"
RAM	32 GB	244 GiB
CPU	1 x *Intel® Core™ i7-2600 @ 3.40 GHz*	32 x *Intel® Xeon™ E5-2670 v2 @ 2.50 GHz*
Disc	1 x 2 TB (HDD)	2 x 320 GB (SSD)
System	Win 7 x64 SP1	Win Server 2012 6.2

Model settings:

- $LiNbO_3$ crystal (128° YX) (Comsol database)
- Rayleigh SAW with λ = 150 µm [1]
- Excitation: $V = V_0 \sin(2\pi f t)$, f=26.6 MHz, V_0=1V
- One pair of electrodes
  @ $\lambda/4$ = 37.5 µm, aperture width of 1 mm
- Low reflecting vertical boundary conditions for P and S waves [2]
- Equidistant mapped mesh: element size: 18.75 µm x 18.51 µm → 8 elements / λ (fig. 1)

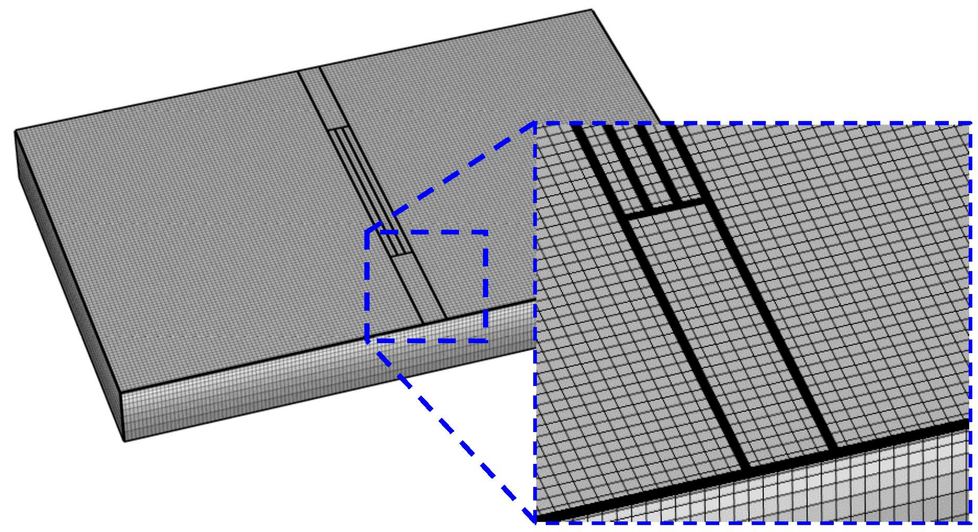

Figure 1: Mapped mesh consisting of equidistant elements (160 x 108) on the substrate surface (3 x 2 mm²), swept by 10 elements with a ratio of 20 throughout the substrate thickness (300 µm).

Results:

	Workstation	**AWS** "r3.8xlarge"
Calculation time	6 days 1 hour	2 hours 30 min

- AWS approx. 70x faster calculation
- Approx. 60 GB RAM utilization (in both)
- 50% CPU utilization (AWS), see fig. 2

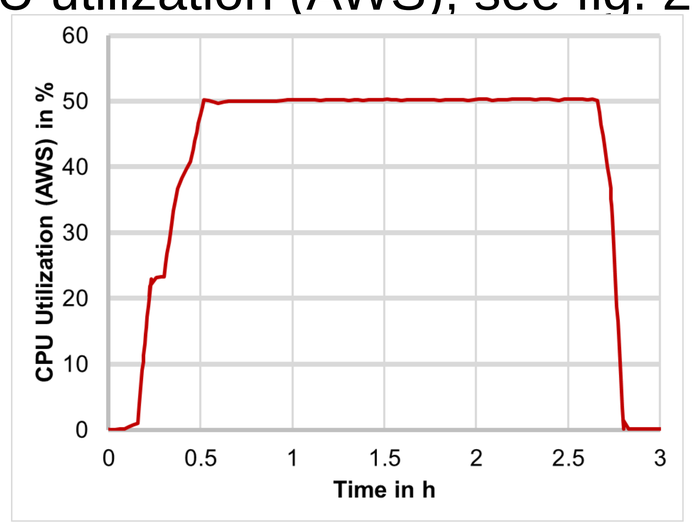

Figure 2: CPU Utilization in during model calculation in AWS

- SAW propagation in all directions
- Diffraction due to limited aperture width
- Non-symmetric wave due to inaccurate material parameters for this crystal cut

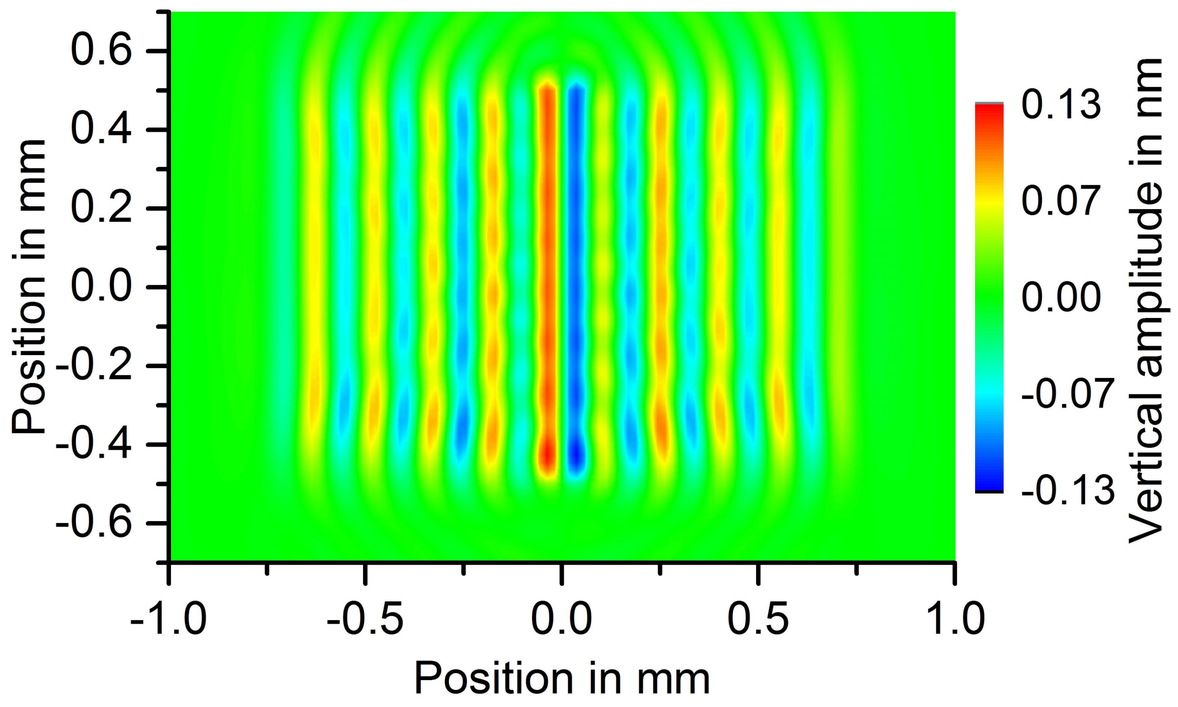

Figure 3: Rayleigh SAW (vertical surface displacement) generated by harmonic electrical excitation of finger electrode in the middle of the substrate.

References:

1. G. S. Chung and D. T. Phan, Finite Element Modeling of Surface Acoustic Waves in Piezoelectric Thin Films, *J Korean Phys Soc*, **57**, 446-450 (2010)
2. V. Marra and S. Datta, Two-port Piezoelectric SAW Device (ID: 19155), *Comsol Multiphysics GmbH Application Gallery*, www.comsol.de/model/two-port-piezoelectric-saw-device-19155, (Accessed 01.09.2015)