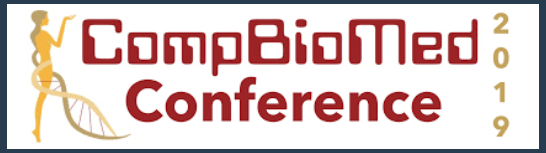


London, September 25 - 27, 2019

Advancing Personalized Healthcare with High-Performance Cloud Computing for the Living Heart Project

Wolfgang Gentzsch and Francisco Sahli
The UberCloud and Stanford University

Case Study: The Living Heart Project

Studying Drug-induced Arrhythmias of a Human Heart with Abaqus in the Cloud

Stanford University

SIMULIA

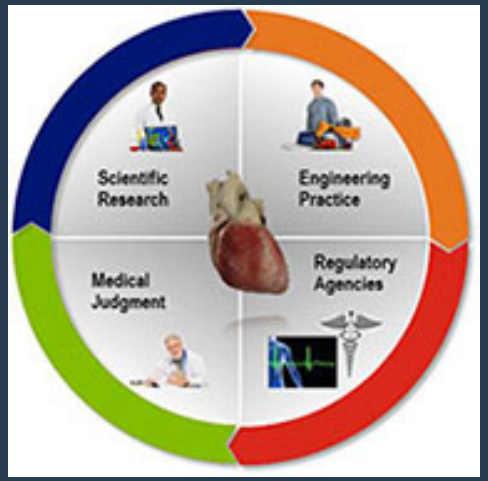
advania
data centres

Uber Cloud

intel

Hewlett Packard Enterprise

The Living Heart Project



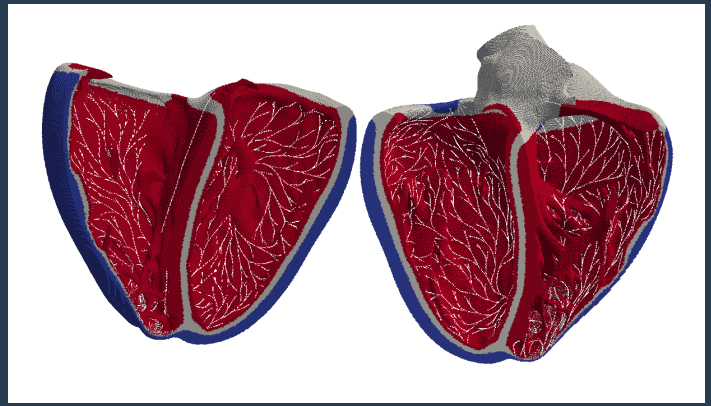
- **Members:** Leading cardiovascular researchers, educators, medical device developers, regulatory agencies, and practicing cardiologists
- **Shared mission** to develop and validate highly accurate personalized digital human heart models (DHHM).
- **Living Heart Models** establish a unified foundation for cardiovascular in silico medicine
- Models serve as a **common technology base** for education and training, medical device design, testing, clinical diagnosis and regulatory science
- Rapidly translating current and future cutting-edge innovations directly into **improved patient care**.

Arrhythmia affects millions of people

- In Europe and North America, atrial fibrillation affects about 2% to 3% of the population (2014)
- Atrial fibrillation and atrial flutter resulted in 112,000 deaths in 2013, up from 29,000 in 1990
- Sudden cardiac death is the cause of about half of deaths due to cardiovascular disease or about 15% of all deaths globally
- About 80% of sudden cardiac death is the result of ventricular arrhythmias

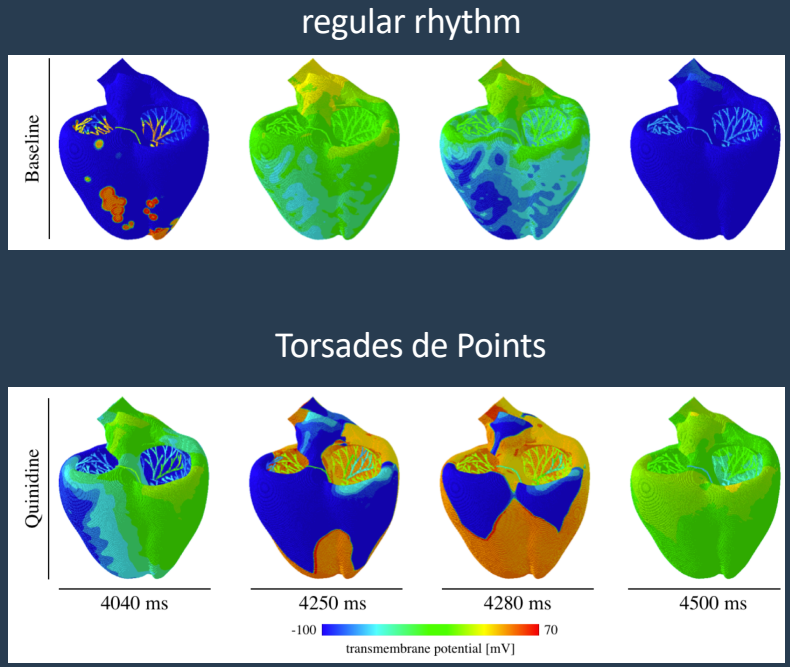
Multiscale model of cardiac electrophysiology

- Bi-ventricular anatomy based on healthy human
- Finite element model with 7,500,000 nodes
- 250,000,000 internal variables, updated/stored within each sim step
- 1,000,000 time steps
- State of the art representation of cellular dynamics
- 3 different cell types in the ventricular wall
- High fidelity model of the Purkinje network



Applying drugs to the living heart

- Torsades de Points is a dangerous type cardiac arrhythmia. Electrical waves in the heart turn chaotic.
- Produced as side effect of drugs, but assessing this risk for new compounds is expensive and can take a long time
- With this model, we can predict overall response the heart just by measuring the effect of a drug in a single cell
- Example: we applied Quinidine to the model, which presents high risk of Torsades de Points
- Our model spontaneously develops Torsades de Points when high risk drugs are applied
- We envision this model will help researchers, regulatory agencies, and pharmaceutical companies to accelerate drug development and create effective and safe drugs for patients.



High Performance Computing as a Service (HPCaaS)

Partners: Advania / HPE / Intel / Dassault / UberCloud

- **Advania**'s HPC as a Service (HPCaaS) hardware configuration
- Built upon 100 **HPE** ProLiant servers XL230 Gen9
- Each with 2 **Intel** Broadwell E5-2683 v4 Intel OmniPath interconnect
- UberCloud HPC software **containers** hosting Stanford's workflow
- Dassault Systèmes SIMULIA **Abaqus** for structure and advanced electro-physiological interaction

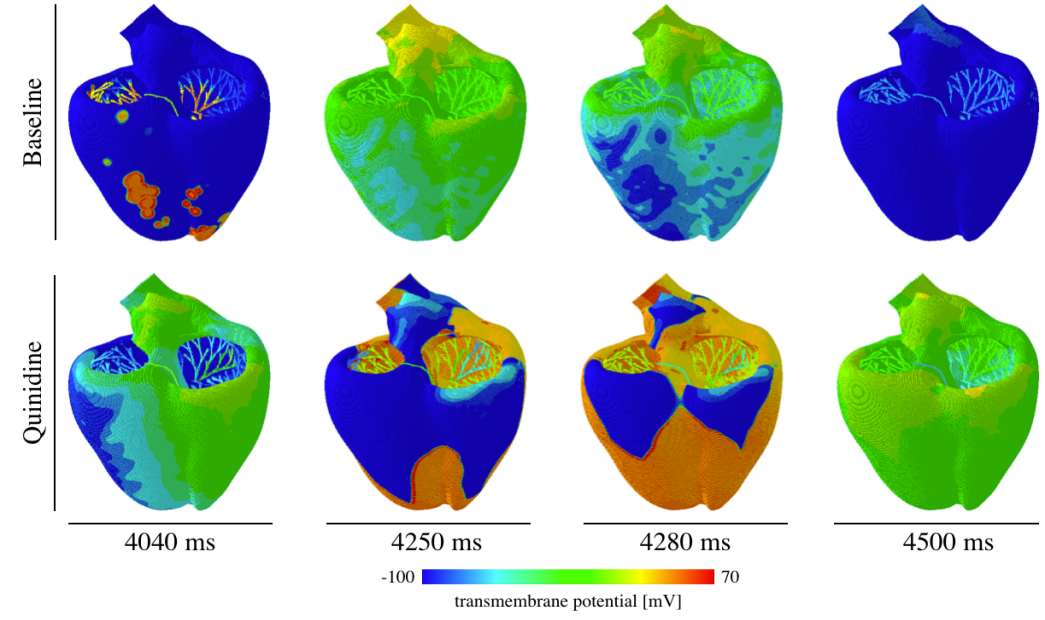
HPCaaS Environment and Simulations

Advania / HPE / Intel / Dassault / UberCloud

Goal: create a biventricular finite element model for **Stanford** to study drug-induced arrhythmias of a human heart.

- Hundreds of cloud HPC hours on different Advania configurations
- LHP model scaled well up to 240 compute cores
- 42 simulations each 40 hours on 5-node (160-core) subsystem
- Study: identifying drugs causing arrhythmias
- Applying drugs by blocking different ionic currents in cellular model, replicating what has been observed before in cellular experiments
- For each case, we let the heart beat naturally and see if the arrhythmia is developing

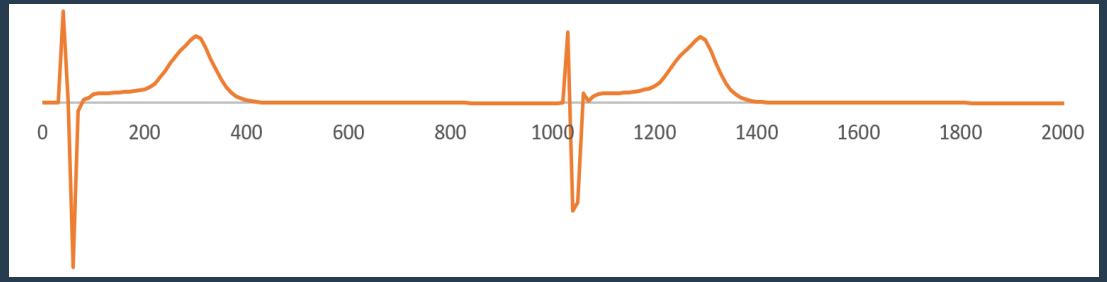
Simulation Results



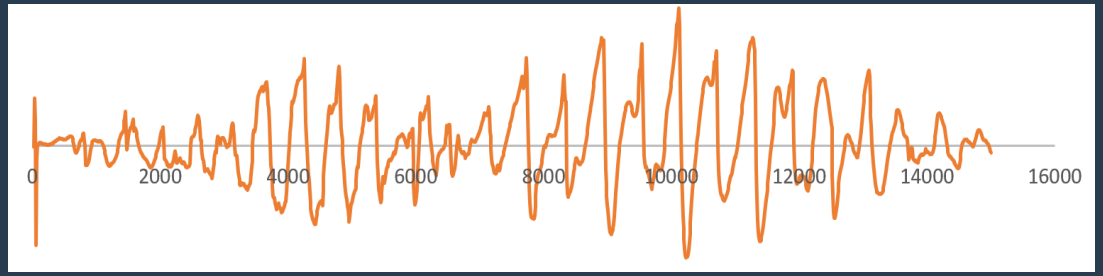
Evolution of electrical activity: After application of Quinidine, the electrical propagation turns chaotic, showing the high risk of Quinidine to produce arrhythmias.

Simulation Results

Electrocardiogram (ECG) without and with the drug Sotalol



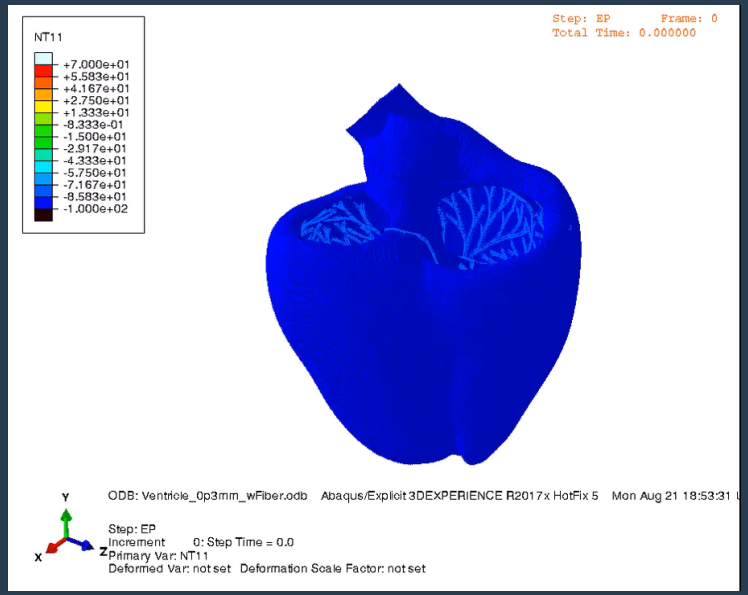
ECG tracing for healthy, baseline case

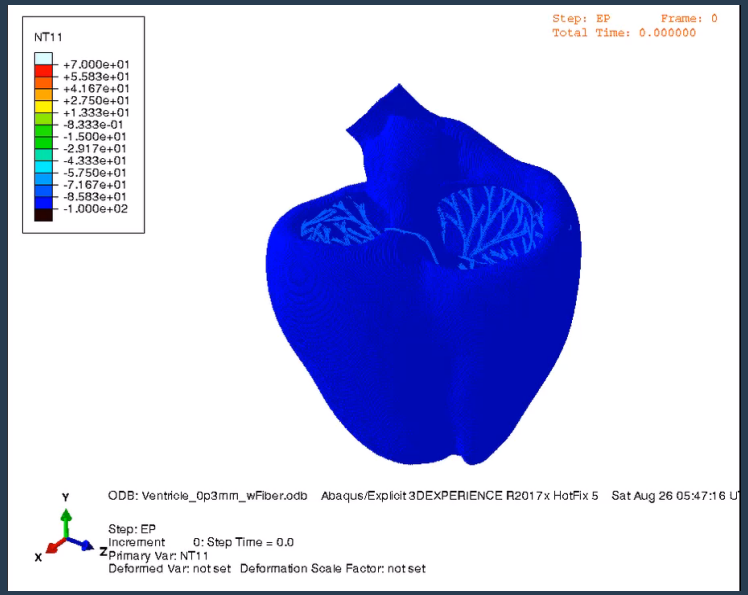


Arrhythmic development after applying the drug Sotalol. The ECG demonstrates that the arrhythmia is of Torsades de Pointes type.

Note: These are simulation results !

Videos of healthy case versus drug-induced case





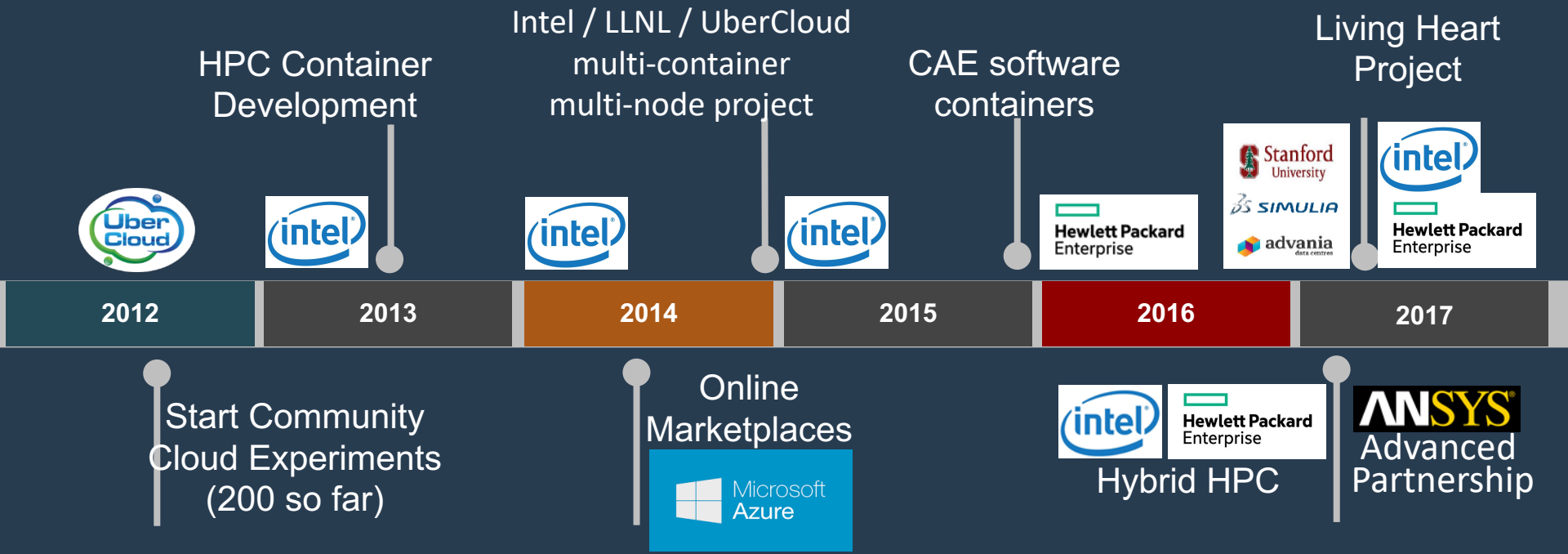
Application of the drug Quinidine (right) where we observe Torsades de Points arrhythmia

The two videos can be obtained from wolfgang.Gentzsch@TheUberCloud.com

Take Aways

- UberCloud is part of HPE's HPCaaS "Hybrid HPC"
- HPC Containers give us a way to solve software management problems without performance issues
- Able to manage and run the most complex engineering workflows
- Providing SaaS-like user experience and desktop level ease of use

Some Background about the Intel - HPE - UberCloud Partnership 2012 - 2017



Abaqus in UberCloud Container

- Based on Docker, **enhanced** for engineering & scientific app software
- Application software is **pre-installed**, configured, tested by UberCloud and Stanford
- Includes **all tools** an engineer needs such as MPI and remote visualization
- Running in the Advania Data Centers Cloud

LHP Simulations ran on HPE Hybrid HPC Stack

ANSYS
UNIVA
SIMULIA
NUMECA INTERNATIONAL
SIEMENS
MATLAB
COMSOL
OpenFOAM
TRANSVALOR
DCV desktop cloud visualization

UberCloud Containers

Micro Focus Cloud Service Automation

Micro Focus Operations Orchestrator

HPC Automated Life Cycle Management Layer

HPE CMU

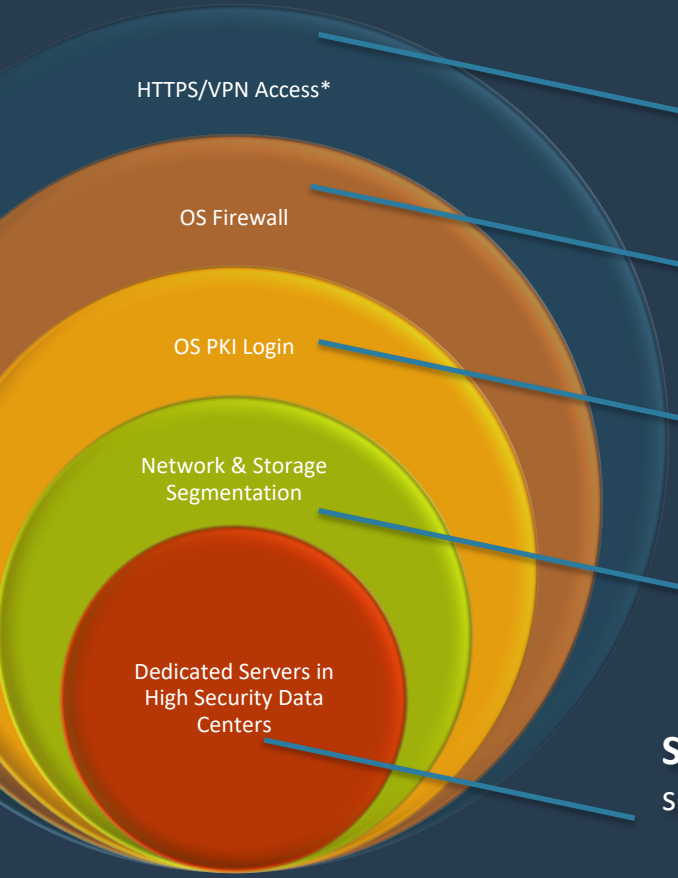
Hybrid Cloud

advania data centres

Hewlett Packard Enterprise

Cloud28+

Fully Secure Environment on Advania, HPE, UberCloud



Connection to our servers are protected by strong **encryption** techniques such as HTTPS and VPN (HTTPS/VPN access and Disk Encryption are optional)

Servers are protected with **firewalls**. Only necessary ports are turned on to reduce attacks

Admin access is protected by **Public Key Encryption** (vs passwords, which can be guessed)

Network and Storage tiers are **segmented** automatically. Each customer gets a private HPE CMU, a private IP range, and a private storage volume

Single tenant, bare metal servers (not shared between customers). These servers reside in professionally managed, highly secured data centers.

Summary of Key Benefits of Using HPC Containers

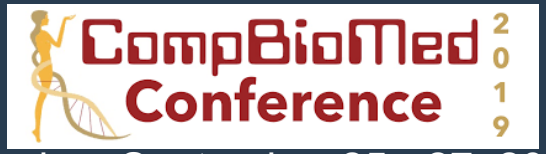
UberCloud: Looks & works like your desktop only much faster

Usability – Flexibility – Performance

- Desktop-like user experience to eliminate training needs & provide ease of use
- All software fully installed & ready to use, pre/post processing, meshing, solvers, MPI
- Instance & cluster sizes are flexible, scales up/down based on analysis requirements
- Shared storage sized based on needs
- GPU, RDMA, InfiniBand & SSD supported out of the box
- No new cloud platform, no need to learn anything new – feel ‘home’ immediately

Finally, Big Thanks to HPE, Intel, HPCwire

And to the HPC User Forum Steering Committee for all the Awards



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Thank You

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