SOUTH Cloud
Shape Optimization under Uncertainty through HPC Cloud

Partners:
- OPTIMAD, Italy
- University of Strathclyde, UK
- CINECA, Italy
- Automobili Lamborghini, Italy
Scenario

- *Simulation based product analysis is a standard, but optimization not...*

- “In-house” optimization $\rightarrow$ cost-inefficient
  - specialized personnel
    - proficiency CAE & optimization software + HPC
    - problem-specific knowledge (*methods, parameters, constraints*...)
    - Integration between CAD, CAE, IT
    - Water-proof fully-automated workflow (geometry $\rightarrow$ CAE simulations)
  
  - simulation cost
    - computing $\sim O(10^2-10^3) \times \text{Cost(simulation)}$
    - computing resources sized for analysis (*optimization peak requirement*)
    - licensing of optimization & simulation SW

- *ROI can be guaranteed only for standard (analysis) tasks*
  - high amortization costs (computing infrastructure, etc.)
  - lack of confidence towards “new workflows”
  - $<10\%$ of regular CAE users (mainly LIs) $\rightarrow$ does not justify investments
Potential Market

• Man-in-the-loop (pseudo-optimization) is performed by >70% of regular CAE users
  – product improvement standard task in CAE
  – time & cost constraints don’t allow ASO

• Market
  – experts in simulation, but “not-so-strong” background in optimization
    • R&D department of SMEs
    • engineering department of LIs
    • consultancy firms

 250 MEuro < market size < 500 MEuro
Benefits

- end-user: integrated, flexible and sustainable solution
  - no amortization costs of any type
  - ca 75% of time savings and 30% cost savings wrt to man-in-the-loop (Lamborghini)
  - No competition with on-premise resources

- ISV: scalable business opportunity
  - from consultancy to product

- competing ISVs
  - (opt) modeFrontier, Optimus, iChrome, (CFD) Star-CCM+, FLUENT, HyperStudio, (geom) CATIA, SolidWorks, (cloud-based integrated solution) none (back then...)

- SOUTH competitive advantages
  - holistic view (provides all necessary resources)
  - open and accessible (open API, to integrate end-user CAE tools)
  - cost effective: pay-as-you-go (no upfront costs), no maintenance (HW/SW)

- SOUTH weaknesses
  - no complete control (experts)
  - no deployment on hybrid clouds
  - cash-flow
Main idea

• Tackle all burdens which have been identified
  – specialized personnel
  – software integration
  – HPC resources
  – license (as far as possible...)

• leitmotif: user should set only intuitive parameters
  – opaque interface towards HPC structure
  – integrated solution with little process specific know-how
  – optimizer & geometrical parameterization already integrated
    • geometrical constraints
    • time & cost
  – user is responsible for the interface with CAE software
    • easy API towards simulation software
    • simulation template

• HPC → upscaling & setup for “Machine Learning” models
  – create large dataset by using simulation templates
  – Automatically identify cheaper simulation models (LowFi), which predict trends correctly
  – train AI, which mimics specialized personnel for optimization setup
Wind shield SO

Original Geometry

Optimized Geometry
18-dimensional parameter space
volume constraints for head
max deformation in normal direction
overall $c_d$ reduction 4%
• 180 cpu-h  1 full CFD
• 4 cpu-h   1 hybrid CFD/POD (speed-up x45)

• ca. 150 full CFD simulations + 1200 hybrid simulations = 32k CPUhrs (85% full+ 15% hybrid )
• 4.2 days on 320 cores @CINECA Galileo

optimization speed-up x7.6 including database creation
Front bumper SO – Lamborghini AVENTADOR

Rendering by Marco Cisternino (Optimad)
What happened next...

• SaaS (expected TRL: 8-9, reached TRL: 7) → not still there, yet...
  – end-user uses autonomously the platform
  – pay/optimization + consumed CPUhrs

• Obstacles:
  – Integration of end-user CAE tools
  – Licensing models
  – Fall-back on Opensource SW not always possible (lack of validation/confidence)
  – Fully automated workflow (automatic mesh generation, water-proof optimization pipeline)
  – Users “want” a fully automated workflow but “need” full control. Application-specific pipelines not sustainable from SW development point-of-view.
  – Psychological barriers
    • convince end-user to spend O(10KEuro)
    • move from on-premises to cloud (amortization vs cash flow) !!!
    • data security for LIs
What happened next...

• **Service (currently ongoing)**
  – provide product optimization as consultancy service using SOUTH
  – project specific costs

• **Hybrid (implemented)**
  – integration with customer simulation SW
  – end-user uses autonomously the platform
  – integration specific cost+ pay/optimization+ consumed CPUhours

• **Several past/ongoing projects:**
  – Nolan group (racing)
  – Lamborghini
  – Rolls Royce (aeronautic engine)
  – ...

• **TRL increased → Funds secured** for further development.
Thanks. Questions?