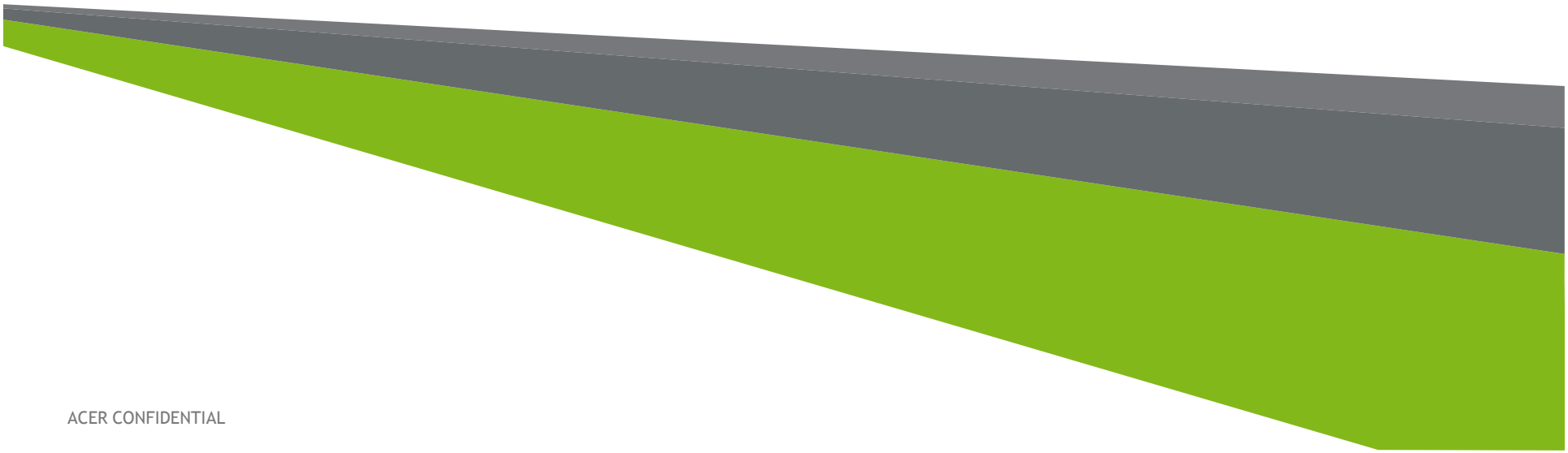
Deploying GPGPUs in Manufacturing

A case study of software and CFD development in bicycle manufacturing



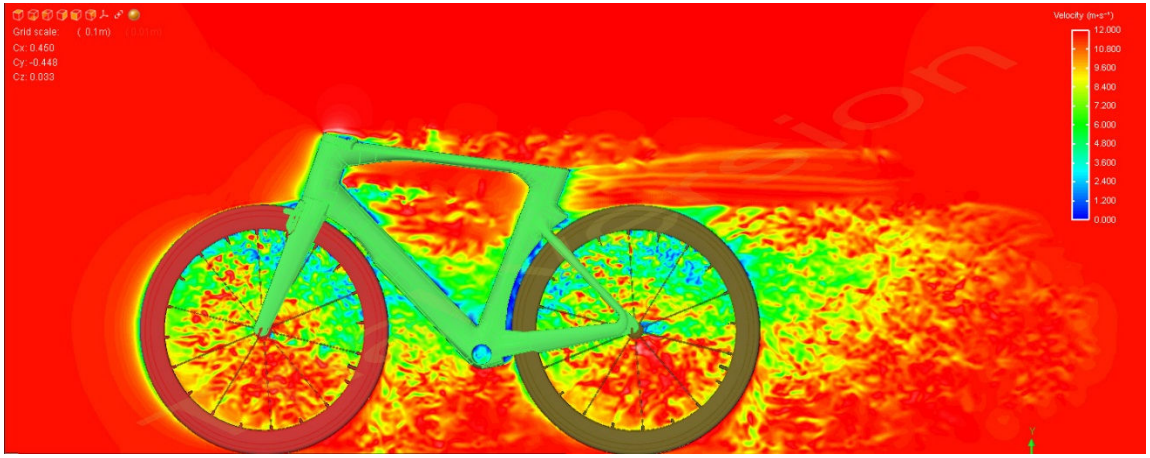
Overview

- Case overview
  - Introduction to Velocite bicycles
  - Introduction of Dr. Matthew Smith, key developer for the project
- Hardware provided
- Software used
- Usage scenarios
  - CFD design and simulation
  - Cloud-based file synchronization
  - Code design and publishing
- Follow up
  - Velocite bikes
  - Matthew Smith
  - Acer Inc. – US and Taiwan

Case overview

Goal

- Develop a new CFD solver and intelligent software allowing computer-*based* design and analysis for bicycle frame design
- Leverage the solver to create a more aerodynamic road bike still capable of holding up to the structural tasks of competition racing



Velocite

- Velocite's slogan is 'feel invincible' and delivers through cutting edge bike design
- Always pushing the bounds of technology, the company looks to develop the most aerodynamic bicycles in the world

Awards

- 2010 Microenterprise National Entrepreneurship Award winner
- 2011 Taiwan Excellent Enterprise Quality Award winner
- 2012 Taipei Cycle Show d&i and iF Award winner
- 2012 Taiwan Golden Pin Design Award winner
- 2012 ISPO BrandNew Performance Finalists
- 2012 The women's entrepreneur competition - Elite Group – special commendation

Recognition

- Member of World Federation of Sporting Goods Industry (WFSGI)

Velocite - product performance leadership

Velocite partners with leading researchers and technology companies to ensure its products are state-of-the-art

- **Tainan Science Park Innovation and Incubation Center**
- **National Applied Research Laboratories (NARL)**
- **Acer Computers**
- **National Cheng Kung University (NCKU)**
- **Oxeon AB**
- **Others and pipeline**

New Helios frame design

- Over 800,000 faces in the design
- Over 1000 hours of CFD
  - Tested wheels and frame
  - Various speeds and angles of attack
- Optimized for 6 degree angle of attack at 40 km/h
- Frame weight: 900g
- Best in class stiffness
  - 150 N/mm torsional deflection
- UCI certified
- Available in Oct. 2013

Prof. Matthew Smith

Education

·B. Eng. (Mechanical and Space Engineering), University of Queensland, Australia (1998-2001)
·M.Phil. (Mechanical Engineering), University of Queensland, Australia (2002-2003)
·Ph.D. (Mechanical Engineering), University of Queensland, Australia (2006-2008)

Experience

·Simulation Engineer, Boeing Australia (2001-2002)
·Research Scholar, University of Queensland, Australia (2003-2003)
·Design and Production Engineer, Nordon Cylinders, Australia (2004-2006)
·Research Scholar, University of Queensland, Australia (2006-2007)
·Associate Researcher, National Center for High-performance Computing, Taiwan (2008-2012)
·Assistant Professor, National Cheng-Kung University (Present)

Expertise

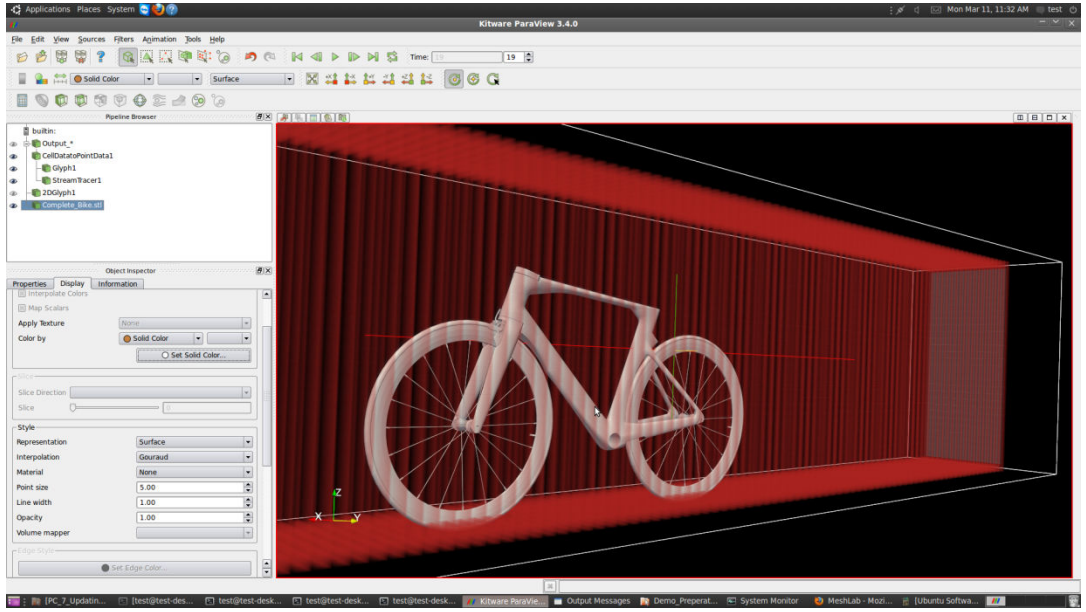
·Rarefied Gas Dynamics (RGD)
·Computational Fluid Dynamics (CFD)
·High Performance Computing (HPC)
·General Purpose computing on Graphics Processing Units (GPGPU)
·CUDA and OpenCL Programming
·Augmented Reality (AR)
·Computer Vision (CV)
·Genetic Algorithms (GA) and Optimization

Hardware used

Acer provided 2 servers for collaboration and development

Server specifications:

- AT350 F2:
  - 2 x Intel Xeon E5-2670 processors
  - 2 x NVIDIA Tesla C2075
  - 1 x SATA HDD for OS operation
  - 64 GB (8 x 8 GB) DDR3 registered memory
  - 1 x NVIDIA Quadro 2000~5000 for 3D rendering

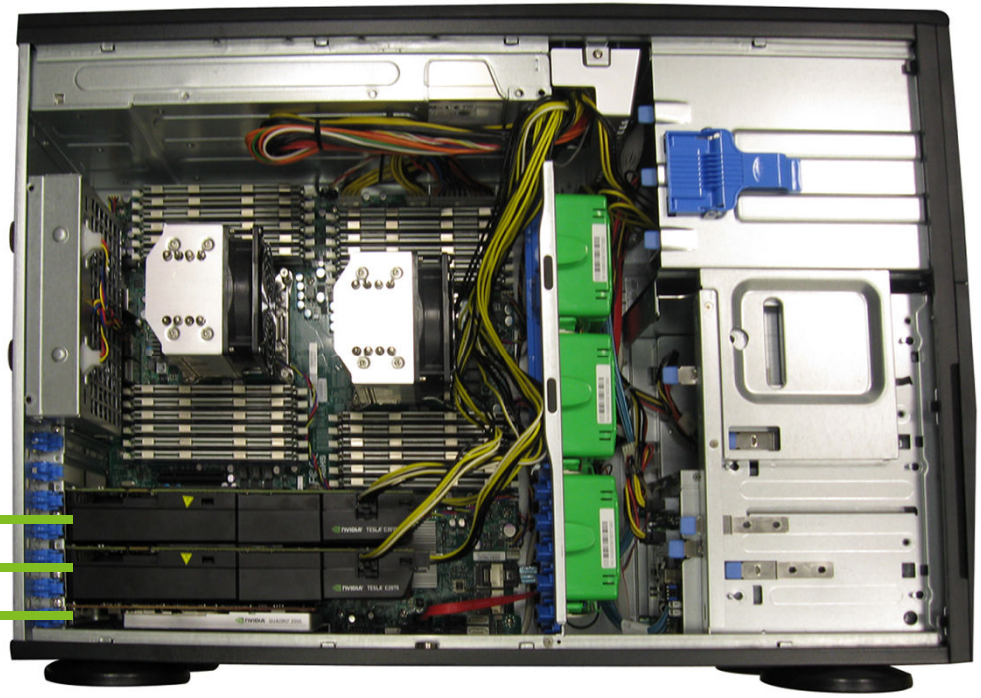


Workstation solution

Acer's AT350 F2 offers best of both worlds

- PCIe controller embedded in CPU
- Extreme memory density
- Up to 3 GPUs in capacity
- Best in class expandability
- 80 PLUS power supplies
- Rack-mountable
- **Supercomputer in a box**

2 x Tesla C2075 (computation)
1 x Quadro 2000 (rendering)



Software used

CFD solver

- Qt for development
- UbuntuOne for file sync

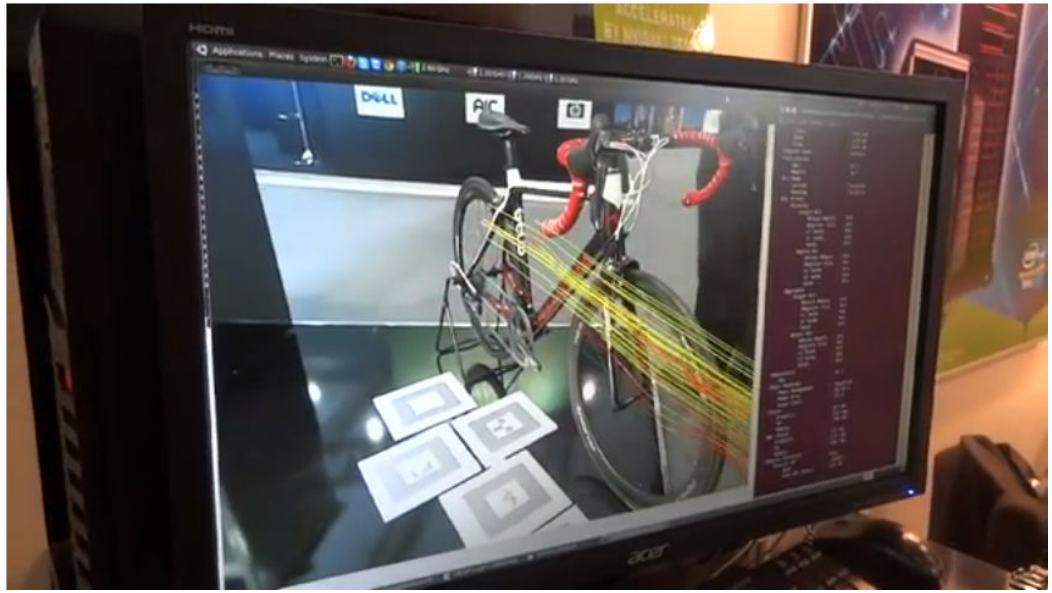
Bazaar for version control

- Xflow used for final

3D model simulation

- Solidworks for preliminary

stress testing



Velocite at ISC’12 with Acer collaboration

CFD solver development guidelines / goals

Development of a CFD package must satisfy the following goals:

- Lightweight
- Multi-Platform
- Low development cost
- No complex function evaluations
- General

Mathematical / physical theories applied

In order to maintain both accuracy and simplicity within the solver, simplistic sum functions were employed rather than complex trigonometric or root-based algorithms

- Uniform Equilibrium Flux Method (UEFM)
  $f\ (v) \approx \Sigma WiH\ (ai\ ,bi)$
- Quiet Direct Simulation (QDS)
  $\int Qvf\ (v\ )dv \approx \Sigma H(v)Qv$
- Split Harten, Lax, van Leer (SHLL)

Usage scenarios

2 design locations

•Software development conducted in Tainan

•Testing conducted onsite in Kaohsiung

•Servers synced and interacted across the teams using UbuntuOne

•Other client PCs and tablets used to interact with the simulation and edit software remotely

Results achieved

Bike design

- Aerodynamic road bike with best in class design – good structural design for stiffness while achieving superior aerodynamics
- UCI approved for use in professional races

Solver design and implementation

- CUDA solver was used to select the 2D airfoil profiles that were used to create 3D shapes
  - Two step selection process: benchmarking of airfoil shapes currently used on high performance bicycles and genetic algorithm optimization of an airfoil shape

Results achieved

Greatest Challenges:

- Realizing high performance rendering speeds for large-scale three dimensional objects within the user interface.
- Integration of a cutting edge flow solver (high resolution, low stability and low usability) with a easy-to-use interface.
- Real-time animated visualizations of large-scale data sets (millions of cells animated at +10 fps).
- Mobile device integration!

Performance versus a cluster:

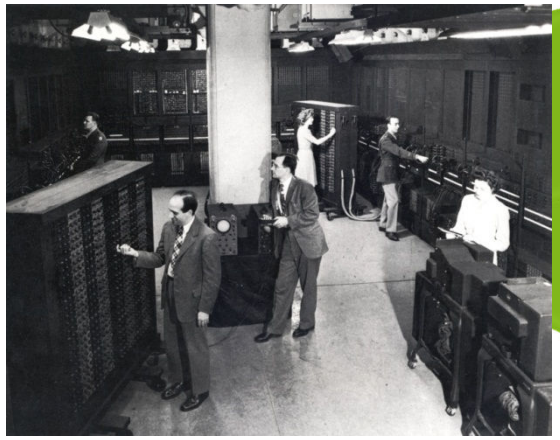
- CUDA-powered CFD solver employed in the airfoil optimization exercises presented a speedup of over 70x (using a single GPU) when compared with its CPU equivalent.
- Solver capable of using multiple (dual) GPU devices. Hence, performance equivalent to 140x.
- Advantage over a cluster of computers – no network communication bottlenecks or hardware required.

Acer Workstations
Veriton P series

Enabling high performance RD for small businesses

Evolution of supercomputing

Proprietary to propagated



Eniac, 1946

TITAN, Oak ridge National Labs (Cray), 2012

Veriton P530 F2, Acer, 2013

Acer Veriton Workstations

Manufacturing rendering
Simulation – ANSYS, Altair
Heavy video post processing
Large 3D design work (> 1000 objects)

Veriton P130 F3

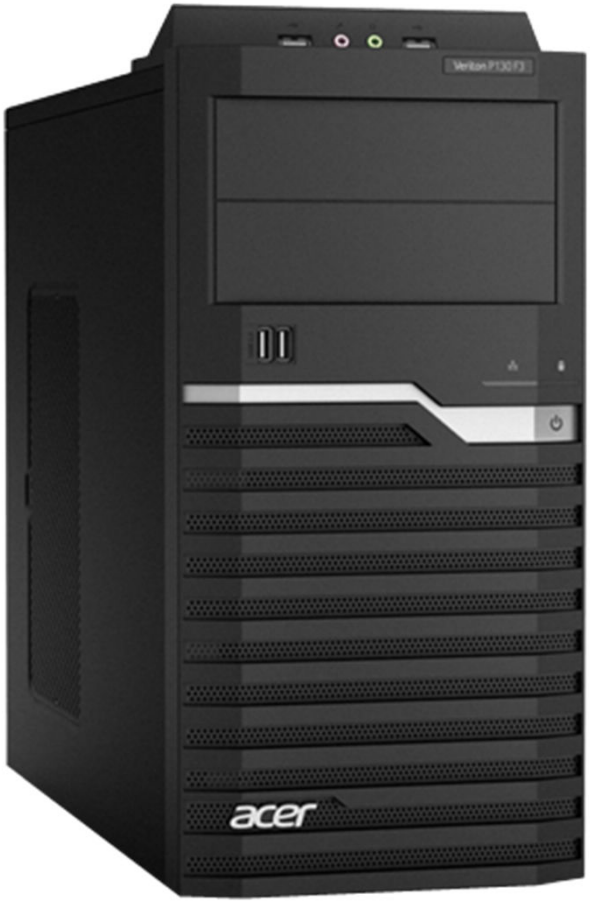
Veriton P330 F2

Veriton P530 F2

AutoCAD
Adobe Photoshop and 2D design
Basic 3D creation, such as ProE, 3DSmax

Veriton P130 F3 product summary

Acer's Veriton P130 F3 workstation supporting the latest NVIDIA® graphics cards along with Intel® Xeon® E3 processors delivers rock-solid performance and easy expandability to ensure the success of your professional business.



Intel Xeon E3 processors

4 DIMMs DDR3 ECC memory

NVIDIA Quadro 400
NVIDIA Quadro 600
NVIDIA Quadro 2000
NVIDIA Quadro 4000

Up to 4 HDDs
Onboard RAID 0, 1, 5, 10

Veriton P330 F2 product summary

Designed for users demanding an excellent combination of performance and expandability, the Veriton P330 F3 is a best-of-class choice for both computing and rendering capabilities

Intel Xeon E5 processors

8 DIMMs DDR3 ECC memory

NVIDIA Quadro 400
NVIDIA Quadro 600
NVIDIA Quadro 2000
NVIDIA Quadro 4000
NVIDIA Quardro K5000
NVIDIA Quadro 6000

Up to 4 HDDs
Onboard RAID 0, 1, 5, 10

Veriton P530 F2 product summary

Up to 16 physical cores, and capable of supporting 3 GPUs, the Veriton P530 F2 offers maximum compute and rendering performance to the most demanding designers and engineers

2 x Intel Xeon E5 processors

16 DIMMs DDR3 ECC memory

NVIDIA Quadro 400
NVIDIA Quadro 600
NVIDIA Quadro 2000
NVIDIA Quadro 4000
NVIDIA Quardro K5000
NVIDIA Quadro 6000

Up to 4 HDDs
Onboard RAID 0, 1, 5, 10

For more in-depth questions

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Velocite Bicycles

- Please visit https://www.velocite-bikes.com/contact-us.html

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