High Performance Computing in European Manufacturing: Status and Trends

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DIGITAL and the European Manufacturing Industry

OUTLINE

- The high-performance technical computing market
- The European manufacturing industry
- Three examples
- Status and trends in the industry
- DIGITAL and the industry
High-performance technical computing

- High-performance technical computing (scientific computing) is the simulation of physical phenomena on virtual prototypes using computers.
- The purpose is to predict the behaviour of materials or objects, and predict the evolution of processes or events.
- Simulations must be close to real experience: industrial validation of applications is essential.
- Simulation can lead to deeper understanding.
The high-performance technical computing market

- Total size in 1997 about $3B, roughly 1/3 in each of Europe, America, Asia/Pacific; will grow to $5B by 2000

- Major segments
  - Education/R&D 30%
  - Engineering Development (Manufacturing) 16%
  - Biological, Chemical, and Material Sciences 14%
  - Geological Sciences and Energy 12%

- Minor segments
  - Electronics and Telecommunications 11%
  - Weather Forecasting and Climate Modeling 9%
  - Defense 8%
Key Guiding Principles

The applications and tools customers want define the size and shape of the market

Independent software vendors are more important to us than we are to them
World-Wide Support Infrastructure

- Software Partner Engineering
- Technical Support and Porting Centers
- HPTC Expertise Centers
- Industry Expertise Centers
Product Design and Analysis

MCAD
- Parametric Technology
- Dassault
- EDS Unigraphics
- Computervision
- Matra Datavision
- Solidworks
- Bentley
- SDRC
- Autocad

Pre/Post Processing
- ICEM-CFD, Altair, CEI, Intel. Light

FEA
- MSC, ANSYS, HKS, MARC

CFD
- FLUENT, Comp.Dyn., AVL, AEA

Crash/Safety
- Mecalog, PSI, LSTC, TNO

Mfg. Proc. Simulation
- Dynamic S/W, Transvalor, C-Mold, Moldflow

Product Data Management
- SDRC Metaphase, Sherpa, Computervision, Eigner & Partner, SAP, NovaSoft, PTC
The European Automotive Industry

- Changing customer requirements
- Global markets and global competition
- Increasing safety and environmental regulations
- Rapidly changing technologies (e.g. electronics)
- Changing new-product development methodologies
- Changing relationship to suppliers
- Danger of manufacturing overcapacity
New Product Development

The Historic Model

Engineering Design
How can target be achieved?

“Must” cost

Market-based price

Market Requirement
What does the market want? What is the value to the customer?

The New Model

Source: P.E. Rubbert, Chief, Aerodynamics Research, Boeing
January 1997

HPC in European Manufacturing
Preparation to enter the market

- Identify the key applications and independent software vendors
- Engage the ISVs, and equip them with up-to-date DIGITAL Alpha/UNIX platforms for development and maintenance (“DIGITAL Application Partners”)
- Characterize the behaviour of the applications on DIGITAL platforms
- Enter into joint marketing efforts to grow ISV license base and DIGITAL customer base at the same time
European DIGITAL Application Partners in automotive domain

- AEA Technology
- CISI
- Dynamic Software
- Intes
- PAM System International
- Polyflow
- Samtech
- TNO Road Safety Research
- Transvalor
- AVL List
- CHAM
- MECALOG
- Numerical Integration Technologies
Some examples

- PSA Peugeot-Citroën
- VolksWagen
- Ferrari Racing Team
Early experience: Cray Y-MP replacement at VW

- Very difficult to change mentality of central supercomputer operators to accept modern computer architecture (RISC SMP clusters)
- Many diverse applications and tools
- Trend is away from centralized supercomputing
- Changed strategy to work directly with the end users: the working design engineers
- Propose solutions for individual engineering groups
The VW Cluster

- Installed a test machine in Automotive Computational Methods Department (Abteilung Personenkraftwagen Berechnungsmethoden) in April 1997
- Memory Channel cluster of four AS4100 (16 EV56/400 CPUs) plus AlphaStation 500/500 for pre- and post-processing
- Evaluation using MSC/NASTRAN, PAM-CRASH, STAR-CD, ADAMS, ANSYS, Fortran and C program development during three-month period
- Cluster was purchased in December, 1997 and will be upgraded this year
PSA Peugeot Citroën
HPTC Objectives

- Make a strong contribution to the three main corporate goals
  - reduce costs
  - shorten time to develop new products
  - improve quality
- Perform simulations “just in time” in design, engineering, and manufacturing
- Simulations must be predictive as well as corrective
Simulation reduces the number of prototypes, and the number of experiments that must be done.

Simulation and experimentation are complementary:
- Experiments help calibrate numerical models early in design and engineering.
- Experiments validate numerical results on real prototypes when design is complete.
- Simulation and experimentation can cooperate to solve complex problems (e.g., vibration and noise).
PSA Peugeot Citroën: supercomputer overload

- **Objectives**
  - reduce turn-around time for both R&D and production applications
  - reduce hardware investments

- **Strategy**
  - run R&D applications and production applications on separate platforms
  - move from central supercomputer to decentralized, geographically distributed environment close to CAE teams

- **Practice**
  - share workload among workstations, local parallel servers, central supercomputer
  - decentralize crash/safety, CFD, injection molding, forging, casting, stamping
PSA Peugeot Citroën: choice of DIGITAL platforms

● Computational Fluid Dynamics
  – Memory Channel cluster of two AS8400 with 14 EV56/440 CPUs and 8 GB memory and two AS4100
  – internal aerodynamics, external aerodynamics, underhood flow simulation using FLUENT UNS and FIRE

● Stamping
  – six AS4100 installed at five different engineering departments
  – dedicated to stamping using OPTRIS from Dynamic Software

● Injection Molding
  – AS4100 installed and dedicated to in-house application
Ferrari Racing

- All simulation in development of Ferrari Formula One racing car done on DIGITAL Alpha UNIX platforms
- Dedicated “Numerical Wind Tunnel” on AS8200 (4 EV56/440, 2GB) using FLUENT UNS: external flow around entire car
- Structural analysis of Formula One engine using MSC/NASTRAN and MARC on two AS4100 (6 EV56/400)
- STAR-CD on AlphaStation 500/500
- FDDI network to five other AlphaStations for pre- and post-processing
Trends in European Manufacturing

- Urgent need to reduce time from conception to delivery of new products
- Iterative construction of material prototypes is time-consuming and expensive
- Virtual product development can reduce or eliminate delays through realistic numerical simulation of virtual prototypes and virtual processes

Wolfgang Reitzle, Head of Product Development, BMW: new car without material prototypes by year 2002
Trends in Application Software

- The high-performance computing landscape is changing
  - number of processor architectures is decreasing
  - Windows NT is beginning to play a role in HPC

- Consequences for Independent Software Vendors
  - fewer platforms simplifies development and maintenance
  - UNIX is still the operating system of choice for large problems
  - “Develop on NT - Deploy on UNIX” is becoming an important paradigm

- There are still many small, highly specialized ISVs
  - trend to virtual prototyping will accelerate consolidation
  - larger ISVs are expanding by acquiring small ones
The Opportunity for DIGITAL

- **Alpha microprocessor architecture and implementation**
  - mature microprocessor in third implementation since 1992
  - continuity in performance leadership through 2004 guaranteed
  - highly optimized for scientific computing

- **Same computing platform for technical and commercial applications**

- **HPTC is a key competency of DIGITAL Engineering**

- **Future DIGITAL hardware and software will benefit from US DoE investment in the Advanced Strategic Computing Initiative (30-100 TFLOPS in 2001-2004)**
Alpha Processor Roadmap

Benefits of using Intel semiconductor manufacturing:
- Significantly lower chip costs
- Significantly lower manufacturing investment
- 2 years earlier access to 0.18um CMOS
  - Allows EV7 to include larger on-chip caches
  - Accelerates development of EV8

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<th>Wafer</th>
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<th>Intel FAB</th>
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<td>15M 15M</td>
<td>15M 100+M 250M</td>
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Parallel Performance Example: MARC K6.3, 8 CPUs
Source: MARC Analysis Research Corp.

Normalized Elapsed Time, Thread Rolling
(Ratio of elapsed clock time to best time in the set)

AlphaServer 8400 5/625

#1
Parallel Performance Example: LS-DYNA V940.1

Source: Livermore Software Technology Inc.

Small Car Impact with Rigid Pole

- Digital 8400/625
- HP Exemplar S
- SGI Origin 2000

The chart shows the time [s] required for different numbers of CPUs (1, 2, 4, 8) to simulate a small car impact with a rigid pole. The time decreases as the number of CPUs increases.
Parallel Performance Example: LS-DYNA V940.1

Source: Livermore Software Technology Inc.
Parallel Performance Example: ABAQUS/Standard V5.7

Source: Hibbitt Karlsson & Sorensen, Inc.
Parallel Performance Example: ABAQUS/Explicit V5.7

Source: Hibbitt Karlsson & Sorensen, Inc.
Parallel Performance
Example: STAR-HPC

- Benchmark for Volvo Data
- 8 GB data
- 8 AS8400 EV56/625 each 12 CPUs, 8 GB; dual-rail Memory Channel
- Iteration times
  - 144 sec on 32 CPUs
  - 82.3 sec on 64 CPUs (88% speedup)
  - 75.6 sec on 84 CPUs (73% speedup)
Some of DIGITAL’s Application Partners in Mechanical Engineering

- adapco
- Adina R&D
- AEA Technology
- Airflow Sciences
- Altair Computing
- ANSYS, Inc
- Autocad
- AVL List GmbH
- Bentley
- Centric Engineering
- CHAM
- C-Mold, Inc
- Computational Dynamics
- Computational Eng Intl
- Computervision
- CSAR
- Dassault
- Dynamic Software
- EDS Unigraphics
- Eigner & Partner
- Engineering Mechanics Research Inc.
- Enterprise Software Products
- Flow Sciences, Inc.
- Fluent, Inc
- Hibbitt, Karlsson & Sorenson, Inc
- ICEM Tech
- ICEM-CFD Engineering
- Intelligent Light
- Intes
- KBS2
- Liverware Software Tech’y Corp
- MARC Analysis Research Corp
- Matra Datavision
- Mecalog Sarl
- Mechanical Dynamics
- MIT
- Moldflow
- NovaSoft
- PAM Systems Intl
- Parametric Technology
- Ricardo ConsItg Engrs
- Samtech
- SAP AG
- SDRC
- Sherpa Corp.
- Solidworks
- Sysnoise
- The MacNeal-Schwendler Corp
- TNO Road Vehicles Res Inst
- Transvalor
- UAI
Future Plans

- Closer coordination of DIGITAL activities to support automotive manufacturers and suppliers world-wide
- Increase collaboration with customers’ preferred software vendors on application quality and performance on DIGITAL Alpha platforms
- Selected collaborations among auto manufacturers, application providers, and DIGITAL on increased simulation capability and integration (virtual product development)
- Invest in expanding ISV license base while growing DIGITAL customer base
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<th>Code</th>
<th>Application</th>
<th>ISV</th>
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<td>NASTRAN</td>
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<td>MSC-USA</td>
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<tr>
<td>ABAQUS</td>
<td>Non-linear Analysis (mechanics, heat transfer)</td>
<td>HKS1-USA</td>
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<tr>
<td>RADIOSS</td>
<td>Crash, safety</td>
<td>MECALOG-France</td>
</tr>
<tr>
<td>FIRE</td>
<td>Engine flow, climate control</td>
<td>AVL-Austria</td>
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## PSA Peugeot Citroën
### Codes and Applications

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<th>Application</th>
<th>ISV</th>
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<td>Fluent, Inc-USA</td>
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<td>Public Domain</td>
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<td>ADAMS</td>
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<td>SYSWELD</td>
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Plus others (some in-house) for for vehicle handling, injection molding, electromagnetic compatibility