Early Experiences with IBM p775 and ENDGame

Paul Selwood
# Facts & Figures

<table>
<thead>
<tr>
<th></th>
<th>IBM Power 6 1E+1F+1C</th>
<th>IBM Power7 2E+2F+2C</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak Performance per node (GFLOPS)</strong></td>
<td>600</td>
<td>960</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Number of Nodes</strong></td>
<td>247</td>
<td>1216</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>Number of Cores</strong></td>
<td>7904</td>
<td>38912</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>Total Peak Performance (TFLOPS)</strong></td>
<td>150</td>
<td>1166</td>
<td>7.8</td>
</tr>
<tr>
<td><strong>Total Disk (TBytes)</strong></td>
<td>750</td>
<td>1500</td>
<td>2</td>
</tr>
<tr>
<td><strong>Disk Performance (GB/s)</strong></td>
<td>24</td>
<td>48</td>
<td>2</td>
</tr>
<tr>
<td><strong>Power (Mwatts)</strong></td>
<td>1.2</td>
<td>2.5</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>MFLOPS/Watt</strong></td>
<td>96</td>
<td>370</td>
<td>3.9</td>
</tr>
</tbody>
</table>
### PS29 v PS30 – 26th April 2012

<table>
<thead>
<tr>
<th>UM Task</th>
<th>PS29 Power 6</th>
<th>PS30 Power 7</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>QG00 Global</td>
<td>3580</td>
<td>3400</td>
<td>5%</td>
</tr>
<tr>
<td>QU00 Gbl Update</td>
<td>530</td>
<td>429</td>
<td>19%</td>
</tr>
<tr>
<td>QY00 NAE</td>
<td>856</td>
<td>767</td>
<td>10%</td>
</tr>
<tr>
<td>Q403 UK4</td>
<td>1439</td>
<td>1165</td>
<td>19%</td>
</tr>
<tr>
<td>QV09 UKV</td>
<td>3874</td>
<td>3292</td>
<td>15%</td>
</tr>
</tbody>
</table>
## AQUM Suite

<table>
<thead>
<tr>
<th>Task</th>
<th>PS29 Power 6</th>
<th>PS30 Power 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reconfigure</td>
<td>8:43</td>
<td>3:36</td>
</tr>
<tr>
<td>Fieldcalc</td>
<td>28:28</td>
<td>10:26</td>
</tr>
<tr>
<td>MakeBC</td>
<td>24:27</td>
<td>9:17</td>
</tr>
<tr>
<td>Create Dump</td>
<td>0:59</td>
<td>0:30</td>
</tr>
<tr>
<td>UM</td>
<td>48:09</td>
<td>35:08</td>
</tr>
<tr>
<td>Archive</td>
<td>0:58</td>
<td>0:19</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1hr 58min</strong></td>
<td><strong>0hr 59 min</strong></td>
</tr>
</tbody>
</table>
Acceptance and beyond

- Power 7 clusters accepted - end August 2012
- Operational – 17\textsuperscript{th} September
- Power 6 all powered down by 26\textsuperscript{th} September

- OJEU PIN issued for successor system
- Aiming for operations in 2015

- 2 stage RAPS release
  - 1\textsuperscript{st} N1024 global ENDGame + I/O Server
  - Full set of benchmarks ready for procurement
Operational Models
Primary NWP Models in Operational Suite: Sep 2012

Global
- 25km 70L + UK4 as dynamic downscaler
- with Hybrid 4DVAR at 60km
- 66hr forecast twice/day
- 144hr forecast twice/day
- +12 member EPS - 60km 4x/day 72hr
- & 24 member EPS 2x/day to 15 days

NAE
- 12km 70L
- 4DVAR – 24km
- 60hr forecast
- 4 times per day
- +12 member EPS at 18km 4x/day

UK-V (& UK-4)
- 1.5km 70L
- 3DVAR (3 hourly)
- 36hr forecast
- 4 times per day
- +12 member EPS at 2.2km 4x/day (near-op)
First Results: 2.2km UK Ensemble Probability of Exceeding precipitation thresholds

9th Jun 2012

Radar 24 hr Accumulation, ending 08Z 09/06/12

MOGREPS-UK prob. of exceeding 32.0 mm accum.
MOGREPS-UK prob. of exceeding 64.0 mm accum.
MOGREPS-UK prob. of exceeding 100.0 mm accum.
• London 2012 Yachting Support
• Capability Demonstration
• 300m resolution
• 100km*100km domain
• Plus 250m SWAN Wave model
2013 Primary Modelling Suites

- **2.2km ensemble**
  - Up to 36hr f/c
  - 6-hourly update

- **33km ensemble**
  - Up to 3day f/c
  - 6-hourly update

- **1.5km model**
  - Up to 36hr f/c
  - 3-hourly update

- **4.4km model**
  - Up to 120hr f/c
  - 6-hourly update

- **60km coupled model**
  - Up to 6 months
  - Daily lagged ensemble

- **17km model**
  - Up to 144hr f/c
  - 6-hourly update
Why ENDGame?

- Build on foundations of New Dynamics

- Aims are:
  - Improved robustness
  - Improved accuracy
  - Maintain/improve conservation

- While maintaining/improving efficiency

⇒ Accuracy/Robustness/Scalability
What has *not* changed?

- **Evolution of New Dynamics**
  - Same equation set & dry variables \((\theta - \pi)\)
  - Same horizontal staggering (Arakawa C-grid)
  - Same vertical staggering (Charney-Phillips)
  - Semi-implicit semi-Lagrangian

- **Physics and DA unchanged**
Iterative solution

\[ X^n \rightarrow \text{Atmos\_physics1} \]

\[ \text{Dep pts + Advn} \rightarrow \text{Atmos\_physics2} \]

\[ \text{Solver} \]

\[ X^{n+1} \]

Outer loop x2

Inner loop x2
Result of iteration (1)

- Resolves number of New Dynamics issues:
  - Non-interpolating in the vertical for theta advection **Removed**
  - Explicitly handled vertical Coriolis terms **Removed**
  - Extrapolated trajectory calculation **Removed**

⇒ Improved robustness
Result of iteration (2)

- Allows much simpler Helmholtz problem (7 point stencil cf. 45 point)
- Much simpler (red/black SOR) preconditioner
  ⇒ greatly reduced communications

⇒ Improved scalability
Further Changes

- Same SL advection for all variables
  - Cf. New Dynamics = forms of SL for all, except Eulerian for dry density
    ⇒ Improved robustness

- Coriolis terms based on mass flux variables
  - improved Rossby mode propagation
    ⇒ Improved accuracy
More Changes

- No polar filtering or horizontal diffusion
  - Control near lid and poles achieved by implicit damping of $W$

  $\Rightarrow$ Improved scalability and accuracy

- V-at-poles (cf. $u$, $w$ and all scalars)
  - Not solving Helmholtz problem at singular point of grid!
  - And improved energy properties

  $\Rightarrow$ Improved scalability and accuracy
V vs. U-at-poles

A “trivial” change to model grid!

Current “New Dynamics” grid

- Scalar variables, w winds
- u winds
- v winds

ENDGame grid

- Scalar variables, w winds
- u winds
- v winds
ENDGame scalability

N768 - New Dynamics vs ENDGame

Scaling

© Crown cc
ENDGame Runtimes

N768 - New Dynamics vs ENDGame

Runtimes

Time (seconds)

Power 7 Nodes

ENDGame

New Dynamics

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Questions and answers