## An Era of Embedded Systems

<table>
<thead>
<tr>
<th>Computing system type</th>
<th>Mainframe</th>
<th>Mini computer</th>
<th>Personal computer</th>
<th>Embedded system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Era</td>
<td>1950s on</td>
<td>1970s on</td>
<td>1980s on</td>
<td>2000s on</td>
</tr>
<tr>
<td>Form factor</td>
<td>Multi-cabinet</td>
<td>Multi-board</td>
<td>Single board</td>
<td>Single chip</td>
</tr>
<tr>
<td>Owner</td>
<td>Corporate</td>
<td>Department</td>
<td>Person</td>
<td>Anything</td>
</tr>
<tr>
<td>Users/system</td>
<td>1000s ~ 100s</td>
<td>100s ~ 10s</td>
<td>10s ~ 1s</td>
<td>1s ~ 1/10s</td>
</tr>
<tr>
<td>Cost</td>
<td>$1 Ms +</td>
<td>$100 Ks +</td>
<td>$10Ks – $1Ks +</td>
<td>$100s – $1s +</td>
</tr>
<tr>
<td>Total units</td>
<td>10Ks +</td>
<td>100Ks +</td>
<td>1 billions +</td>
<td>1 Trillions +</td>
</tr>
</tbody>
</table>

*The table is adapted from J. A. Fisher, P. Faraboschi & C. Young with extensions and modifications*
Embedded Systems are Ubiquitous

- Consumer electronics
  - Digital camera and camcorder
  - Cell phone
  - MP3 player
  - Wireless router
  ...

- In robots
  - Vision system
  - Arm and leg control system
  ...

- In telecommunications
  - Internet switch and router
  - Mobile phone base station
  ...

- In automobile
  - Engine control system
  - Anti-lock braking system
  - Navigation system
  ...

- In aircraft
  - Auto pilot system
  ...

- In watercraft
  - Radar system
  ...

- In satellite
  ...

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Multiprocessor System-on-Chip

- Put all or most part of a complex system on a single chip
  - Enabled by shrinking feature sizes
  - Better performance, lower power consumption, and more compact and “reliable”
- Hybrid integration
  - Digital, RF, and mixed signal
  - SIP, 3D, etc.
- Network-on-chip
Thanks!