Definition of Pervasive Grid

- a Pervasive Grid is a hardware and software infrastructure or space/environment that provides proactive, autonomic, trustworthy, and inexpensive access to pervasive resource sharing capabilities ANY time/where/means!

- ultimate goal as RIGHT time/where/means! → Pervasive Intelligence.

- these resources may be either high performance clusters or smart objects, a physical object with AEB and some smartness or intelligence such as

Device, card, label, sensor, artifact, appliance, goods, furniture, textile, robot

Core Technology Challenges

- Three basic types of functions

  - Computation & storage for processing and memory
  - Networking & naming for interconnection and communication
  - Sense & effect for perception and interaction

- Technology challenges (not exhausted)

  Both in hardware and software → *power management, real-time embedded systems, sensor nets, universal ID, devices miniaturization , ubiquitous/pervasive networks, ad hoc mobility, open service architecture, sensed information overload & database, context semantics & management, autonomic system administration, user interface, operating system, language, middleware, integration, cooperation, scalability, heterogeneity, dependability, availability, security, privacy, test, evaluation, standards, etc.*

Real World Challenges

- Ideal sharing resources expected

→ the PG able to act adaptively and automatically according to

1. Surrounding Situations
2. Users' Needs
3. Things' Relations
4. Common Knowledge
5. Self Awareness
6. Looped Decisions

Real-world Challenges

- Above challenges from real world intrinsic characteristics

  - RW == physical + social + natural + … → uncertain, unpredictable, changing,
    unprecedented Complexity …

  - Very large scales,
    - million of entities
  - Ad hoc (amorphous) structures/behaviors
    - p2p/hierarchical architecture
  - Dynamic
    - entities join, leave, move, change behavior
  - Heterogeneous
    - capability, connectivity, reliability, guarantees, QoS
  - Unreliable
    - components, communication
  - Lack of common/complete knowledge
    - number, type, location, availability, connectivity, protocols, semantics, etc.

  - RW computing: complicated/abstruse phil., social, ethical & other implications
  - Understanding real world (RW) diversity and complexity → Extremely Hard !!

Core Challenge 1 – Context-aware

- **Context**
  - Information characterizing the situation of an entity (Dey) or 5Ws (Abowd)
  - Whole contexts are a collection of various values from sensors or other sources
- **Situation**
  - Relatively compact, more semantic, directly used for judgment/decision

- Are the contexts sufficient and precise enough to characterize?
- How correctly be determined using available but incomplete & uncertain contexts?
- What are consequences of situation judgment errors to context-aware/situated resources?

Challenge 2 – Knowing Users' Needs

- Interactive Mechanism

  - A request-response dialog process betw. users (activator) & computer (passive)

  - 3 user limits: too small/many/complex computers to be visible/interact-able/manageable

- Proactive, Autonomic and Trust Mechanisms

  - Take actions proactively by anticipating users' needs (Tennenhouse, Intel, 2000)

  - Manage themselves under human supervisions/needs (Paul Horn, IBM, 2001)

  - Self configuring, self adapting, self optimizing, self healing, self protecting, highly decentralized, heterogeneous architectures

  - Trustworthy to avoid the risk of losing control and retain confidence that the system will not fail, aims at making pervasive grid as well as services available, predictable, traceable, controllable, assessable, sustainable, dependable, persist-able, security/privacy protectable, etc.

- Hardness of knowing users' true needs

  - How much can be known correctly and promptly for users' true needs in changing situations?

Challenge 3 – Complex Things' Relations

- Complex Relations among all shared resources

  - connected and interacted

    - *"Everything will be connected to everything else" - by R. Lucky, 1999*

  → Cyber dimensions, except spatial/temporal/other conventional dimensions

  → Complex dynamic relations among users, u-things, and services within pervasive grid

How to define, find, describe and use complex relations necessary for the pervasive Grid

?

Challenge 4 – Common Knowledge

- Why common knowledge needed?

  - Knowledge is the base of analysis, reasoning, anticipation and judgment (Ref AI)
  - HP Clsuters or Smart u-things are in the physical environments and serve people's daily life and work
  - HP Clsuters or Smart u-things need some common knowledge about physical world, human society, etc.

- Issues are

  - What knowledge is necessary for HP Cluster and smart u-things ?
  - What knowledge should be initially set?
  - What knowledge can be added later on?
  - What knowledge may be self-learned during uses?
  - How knowledge is used for rich and varied real situations?

→ Challenge - how to abstract, learn, use complex knowledge about human & world.

Challenge 5 – Self-Aware

- Why should be self-aware

  - Physical, not virtual, things with attached/embedded/blended (AEB) computers/etc.
  - AEB devices are function parts or components of the real physical things
  - AEB is for enhancing original functions of real things following common rules
  - should be aware their roles and function without against the rules

- Context-awareness *vs* self-awareness
  - Context-awareness: knowing others
  - Self-awareness: knowing selves
  - What exactly means? How to equip self-awareness to u-things and HP Clusters?

- Extreme Challenging and rare research

  "we seem so ill equipped to understand ourselves", The Society of Mind, Minsky, 1986
  Workshop on Self-Aware Computer Systems - Chaudhri & McCarthy, SRI/DARPA, 2004

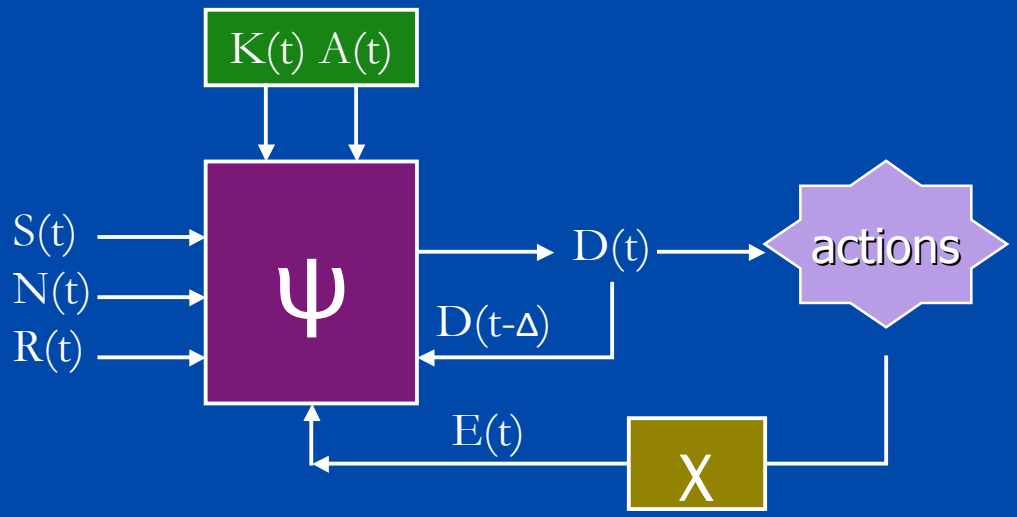
Challenge 6 – Looped Decisions

- Decisions cannot be correct always in 100%
- Imprecise decision & exception are common

  → **Loop mechanism is indispensable !**

  How many loops? Layered models?

$$D(t) = \Psi[S(t), N(t), R(t), K(t), A(t), D(t-\Delta), E(t)]$$



- Challenge is how to adaptively correct errors & make necessary adjustments
- *How related to automatic control theory?*

Efforts

- have a special issue at IEEE Computers around the round table
- build a task force within IEEE/ACM
- continue the GPC series annually to promote the further research