Modeling of Smart Village Technology: Engineering the Smart Fabric of IoT, People, and Cloud Computing

Srikanta Patnaik Professor
Modeling of Smart Village Technology:

Engineering the Smart Fabric of IoT, People, and Cloud Computing

Prof. Srikanta Patnaik, Professor
Department of Computer Science and Engineering
SOA University, Bhubaneswar, Odisha, India
Email: patnaik_srikanta@yahoo.co.in
Editorial Activities of Prof. Srikanta Patnaik & Various publishing Outlets

International Journal of Information and Communication Technology (www.inderscience.com/ijict)

International Journal of Computational Vision and Robotics (www.inderscience.com/ijcvr)

Springer Book Series on Modeling and Optimization in Science and Technology [MOST] (www.springer.com/series/10577)

Advances in Medical Technologies and Clinical Practice (AMTCP) (http://www.igi-global.com/book-series/advances-medical-technologies-clinical-practice/73682)

Advances in Computer and Electrical Engineering (ACEE) (http://www.igi-global.com/book-series/advances-computer-electrical-engineering-acee/73675)
© 2017
Nature-Inspired Computing and Optimization
Theory and Applications

Editors: Patnaik, Srikanta, Yang, Xin-She, Nakamatsu, Kazumi (Eds.)

https://www.springer.com/in/book/9783319509198
Digital Business
Business Algorithms, Cloud Computing and Data Engineering

Editors: Patnaik, Srikanta, Yang, X.-S., Tavana, M., Popentiu-Vlădicescu, F., Qiao, F. (Eds.)

Ecosystem "Society 5.0" (Japan)

Toward realization of the new economy and society, Keidanren (Japan Business Federation), April 2016
3 biggest fears of our generation:
Think Ecosystems: People, Systems, and Things

Diverse users with complex networked dependencies and intrinsic adaptive behavior – has:

1. **Robustness & Resilience mechanisms**: achieving stability in the presence of disruption

2. **Measures of health**: diversity, population trends, other key indicators

Marine Ecosystem: [http://www.xbordercurrents.co.uk/wildlife/marine-ecosystem-2](http://www.xbordercurrents.co.uk/wildlife/marine-ecosystem-2)
Smart Evolution – People, Services, and Things
Autonomic Nervous System
Everything-as-a-Service (EaaS)
Ubiquitous Managed Services Solution Across Business Verticals

Numerous Forms Of Smart Services...

Managed Services
- Portfolio management
- Event management
- Analytics

Provisioning
- Services
- SIM profile configuration
- Network configuration

Transaction Management
- Activation
- Deactivation
- Visibility
- Billing
- Reporting

IoT and Cloud Computing enable smart services ecosystem and collaboration opportunities

Some 50 billion devices and sensors exist for M2M applications
“The scientists of today think deeply instead of clearly.

One must be sane to think clearly, but one can think deeply and be quite insane.”

Nikola Tesla
Linear History? Ancient “Computers”

Stonehenge: A Neolithic Computer
*Nature* 202, 1258 - 1261 (27 June 1964);
doi:10.1038/2021258a0

Adam’s Calender, Michael Tellinger
Assumptions, Models, and Abstractions

• Co-evolution of Science & Technologies

• Smart Villages as models of ecosystems: -> People, Things, and Systems

• Models as abstractions are useful (Platonic Forms)

• We lack a model for such an ecosystem

• From automation to creativity support

• Consciousness and creativity support -> lead to new (meta) models and understanding of technologies and science -> Architecture of Values

“Science is organised knowledge. Wisdom is organised life.”

IMMANUEL KANT
Layers of Paradigms

- Not reductionist
- We have to create the abstractions and models we want based on our understanding of human and societal needs
- Ecosystems = Architecture, Structure + Dynamics
- New Paradigms:
  - (1) Elastic Computing, (2) Social Computing, (3) Osmotic Computing
- Emergent properties on higher levels with own properties
Paradigm 1: Elasticity (Resilience)

(Physics) The property of returning to an initial form or state following deformation

**stretch** when a force stresses them
e.g., *acquire new resources, reduce quality*

**shrink** when the stress is removed
e.g., *release resources, increase quality*
Elastic Computing > Scalability

Resource elasticity
Software / human-based computing elements, multiple clouds

Quality elasticity
Non-functional parameters e.g., performance, quality of data, service availability, human trust

Costs & Benefit elasticity
rewards, incentives
Specifying and controlling elasticity

Basic primitives

Elasticity directive primitives

- Monitoring
- Constraint
- Strategy

Resource
- Compute
- People
- Storage
- Network
- Performance
- Data quality

Quality
- Resource/quality/cost

Cost
- Scale in/out
- Stop/wait/notify

SYBL (Simple Yet Beautiful Language) for specifying elasticity requirements

SYBL-supported requirement levels
- Cloud Service Level Service Topology
- Level Service Unit Level Relationship
- Level Programming/Code Level
Specifying and Controlying elasticity of human-based services

What if we need to "invoke" humans?
Elasticity Model for Cloud Services

Elasticity Pathway functions: to characterize the elasticity behavior from a general/particular view

Elasticity space functions: to determine if a service unit/service is in the “elasticity behavior”
Paradigm 2: Social Computing Units (SCUs)
Elastic SCU provisioning (Paradigms 1 and 2 together)

- **Algorithms**
  - Ant Colony Optimization variants
  - FCFS
  - Greedy

- **SCU extension/reduction**
  - Task reassignment based on trust, cost, availability

- **SCU (pre-)runtime/static formation**

- **Cloud APIs**

- **Elastic profile**

- **SCU Provisioning Framework**
Algorithmic Team Formation

Provisioning algorithms:
- Ant Colony Optimization variants
- FCFS
- Greedy

Supported query variables:
- Skills
- Skill level (fuzzy)
- Connectedness (fuzzy)
- Max Response Time
- Cost Limit
- Optimization objectives
  - cost
  - time
  - responsiveness

Trust model metrics:
- Willingness
- Success Rate (of willfully accepted tasks)
- Delegation Reliability (Willingness Confidentiality)
- Success Rate of initially assigned tasks
- Quality of Results (automated measures)
- Reliability
- Effort
- Productivity
- Technical/Performance Trust (PT)-Software measured
- Socio-Technical Trust Score (STT)
- Social Trust (ST)-Subjective, through voting
- Client Satisfaction Score (Quality of Results, Interaction Satisfaction...)
- Membership Collaboration Trust Score (Quality of Intermediate Results, Interaction Satisfaction...)
Paradigm 3: Osmotic Computing

- In chemistry, “osmosis” represents the seamless diffusion of molecules from a higher to a lower concentration solution.

- Dynamic management of (micro)services across cloud and edge datacenters
  - deployment, networking, and security, …
  - providing reliable IoT support with specified levels of QoS.
Perspectives on the IoT: Edge, Cloud, Internet

(a) A cloud-centric perspective: Edge as “edge of the cloud”

(b) An Internet-centric perspective: Edge as “edge of the Internet”
Cloud-centric perspective

Assumptions

- Cloud provides core services; Edge provides local proxies for the Cloud (offloading parts of the cloud’s workload)

Edge Computers

- play supportive role for the IoT services and applications
- Cloud computing–based IoT solutions use cloud servers for various purposes including massive computation, data storage, communication between IoT systems, and security/privacy

Missing

- In the network architecture, the cloud is also located at the network edge, not surrounded by the edge
- Computers at the edge do not always have to depend on the cloud; they can operate autonomously and collaborate with one another directly without the help of the cloud
Internet-centric perspective

Assumptions

• Internet is center of IoT architecture; Edge devices are gateways to the Internet (not the Cloud)
• Each LAN can be organized around edge devices autonomously
• Local devices do not depend on Cloud

Therefore

• Things belong to partitioned subsystems and LANs rather than to a centralized system directly
• The Cloud is connected to the Internet via the edge of the network
• Remote IoT systems can be connected directly via the Internet. Communications does not have to go via the Cloud
• The Edge can connect things to the Internet and disconnect traffic outside the LAN to protect things → IoT system must be able to act autonomously
“Traditional” ICT view on Smart Village

- Monitoring and controlling a large scale network of interconnected “things” (devices, services, sensors, actuators)
  - Enablers: IoT, Cloud, Big Data, participatory sensing

- Focus on “optimizing” physical/digital infrastructure, not society!
  - society is expected to implicitly benefit from infrastructure optimization
“Societal view“ on Smart Village

- Active involvement of individual citizens in processes and ad-hoc activities to achieve coordinated collective benefits:
  - optimize transportation, energy use, resource sharing
  - direct democracy, shaping and uptake of regulations
  - new business opportunities (novel business models) dependent on collective participation
“Holistic View“ Architecture of values

- Inclusion of all stakeholders into the active management of the Smart Village

- Integrated management of physical, ICT and social infrastructure

- Generation of new values
Cyber-Human Smart Village Values

Infrastructural values

- **traditional management** (optimizations and savings) of Village-owned physical infrastructure.

- **integral management** of privately owned IoT-enabled devices put at disposal (computational resources and everyday objects, such as cars) for common benefit.

- dynamic, locally-scoped infrastructural optimizations and interventions through citizens and privately-owned IoT infrastructure (e.g., citizens vote for new sensors)
Cyber-Human Smart Village Values

Societal values

- Direct inclusion and empowerment of citizens as key stakeholders of the Village both in digital and physical environments

- Interaction, demonstration, informed-ness, learning through pervasive IoT devices and Virtual Reality

- Direct democracy, voting simulation

- Formation of ad-hoc human teams for performing complex collective activities (physical and cognitive)
Cyber-Human Smart Village Values

Business values

- **New labor/work models** supported by:
  - Mechanisms for management of complex coordinated activities:
    - incentive mechanisms
    - team formation algorithms
    - negotiation protocols

- **New business models** based on:
  - Augmenting the overall Village infrastructure with citizen-owned devices
  - Microtransactions
  - Dynamic and crowdsourced workforce spanning entire population
Smart Village Platform

• Can a machine-only system really be considered “intelligent”?
  • Going beyond Turing Test... (or Alexa, Siri, Cortana)
  • Why not gather societal intelligence? ... and not try to match the intelligence of a single human individual?

• Intelligence utility is limited if restricted only to digital domain → go physical

• “Embrace” AI and integrate human collectives into the process!
  • Help with tasks trivial for humans, but challenging for computers
    • not only intellectually, but also physically
Thank you!

Questions?