Trends and Future challenges in autonomic communications

S-38.4030

Contents

The aim of this presentation is to give an overview of Trends and Future challenges in autonomic communication.

1. Terms autonomic communication and autonomic computing

2. Emerging trends in networking and computing environment

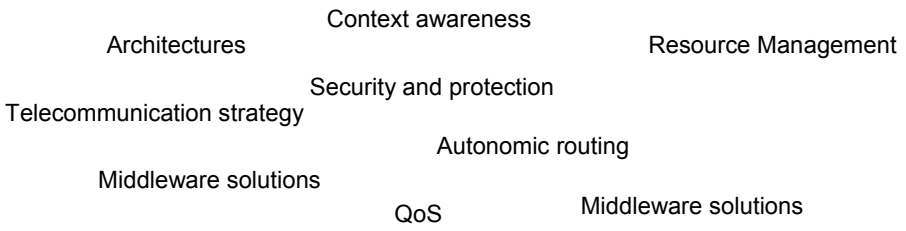
3. One way to describe and handle complexity of systems

4. Evaluation towards autonomic systems and the methods to benchmark autonomic or almost autonomic systems

5. Personal view of challenges in areas of co-operation and markets

1 Autonomic communication

- Research Agenda for a New Communication Paradigm
- Complexity of communication systems
- Communication systems in year 2020



Prof Smirnov is one of the key persons behind the “new” research paradigm.

Characteristics of Autonomic Computing *1(4)*

- **Self-Configuring**
  - Capability to environmental changes
  - Installing, (re-)configuring, and integrating network intensive systems
  - adaptability to re-configure the system

Characteristics of Autonomic Computing *2(4)*

- **Self-healing**
  - Capability to discovering, diagnosting and reacting to disruptions
  - Main objective is to maximize availability, survivability, maintainability and reliability of system

Characteristics of Autonomic Computing *3(4)*

- **Self-optimizing**
  - Capability to efficiently maximize resource allocation and utilization for requirements of users
- **Self-protecting**
  - Capability of establishing trust
  - Protection against attacks

Characteristics of Autonomic Computing 4(4)

- **Self-awareness** of systems state
- **Open** to operate in heterogeneous Environment
- **context-awareness** to react to environmental changes
- **anticipatory** to optimize resources while keeping complexity hidden

Beside of four major characteristics of Autonomic Computing, four additional sub-characteristics can be enumerated

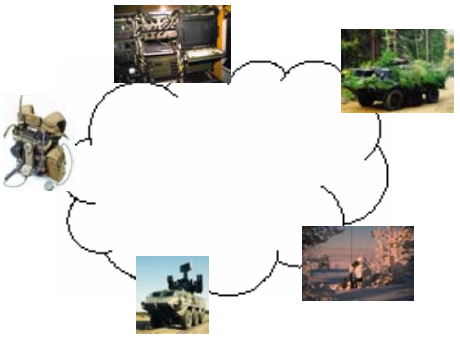
-**self-awareness** means that an autonomic system is aware of its state and its behaviors for self-managing and also for collaborating with other systems

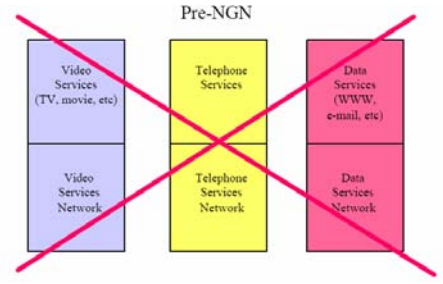
-**open** autonomic system must operate in an heterogeneous environment (interoperable)

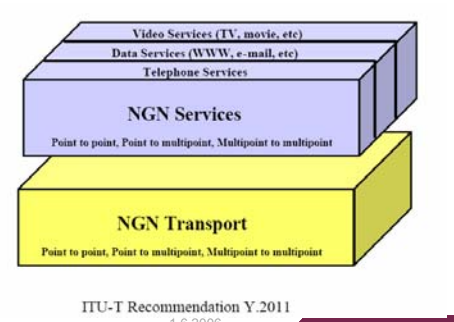
-**context-awareness** means that an automatic system should be aware of its execution environment and is able to react to environmental changes such as new business policies

-**anticipatory** means that an autonomic system will anticipate the optimized resources needed while keeping its complexity hidden.

2 Emerging trends







ITU-T Recommendation Y.2011

Trends from user's point of view

- The number of users and user equipments is increasing
- The number of different kind of applications and services is increasing
- Priorities of applications, users and processed information is needed
- Classified information is stored in networks and user devices
- Different kind of user profiles is needed
- Integration of devices
- Human support is decreasing and available time is decreasing

⇒ Complex computing environment

⇒ Autonomic computing (self-management)

Different kind of user profiles is needed = for users and also for single user

Integration of C2 and communication devices = Mobile phone + PDA + MP3-player + camera etc + multiple connections

Human support is decreasing and available time is decreasing = technical support etc

Trends from network management's point of view *1(2)*

- Wireless communication is essence
- Different kind of radio equipments and multiple connections
  - Limited bandwidth (shared channels, interference between channels)
  - Development of SDRs
  - Adaptive waveforms
- Antenna solutions (directional, adaptive etc)
- Batteries
- The number of user's and challenges of network coverage

Trends from network management's point of view 2(2)

- Connections to other networks
- Authentication of nodes and also users
- Encryption issues
- High mobility
- Human support and available time is decreasing

⇒ Complex communication environment

⇒ Autonomic computing and communication

⇒ Resource and QoS –management solutions is needed also from users point of view

3 Complexity of systems

- The evolution of networks and internet
  - Ubiquitous services
  - Complex computing environments
  - Software intensive systems
  - business services at minimum cost

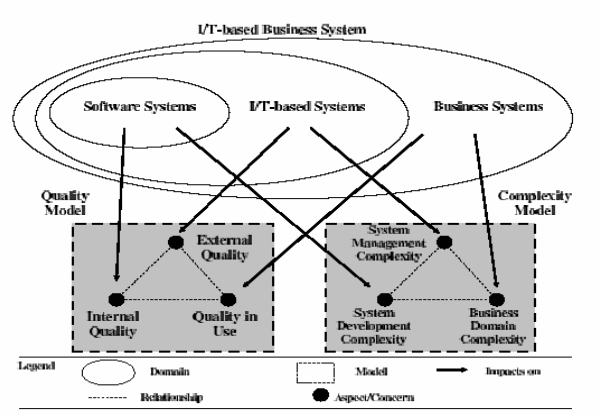
  => Crisis in cost, availability and user experience

The evolution of services and internet has delivered services with extensive scalability and flexibility. The number of users and different kind of services is increasing.

At the same time computing environments are more and more complex and software intensive. We can talk about soft ware crisis in tree areas: cost, availability and user experience. The root cause of crisis is complexity. According to study published in University of California in 2002, depending of system, one third to one half of total budget is spent preventing or recovering from crashes. Same kind of results are presented in resent reports of International Data Corp.

A categorization of complexity

Standardization
ISO/IEC 9126-1



Atributes
- Cost
- Time
- Size

Figure illustrates a synergy between three components

-**Information Technology based business system** including layers of IT-based systems and software systems. Network and hardware resources are not presented in this picture

-**Software quality model** based on standardization

-**Complexity model**

-Business domain complexity = How to translate business policies to I/T policies

-System development complexity = How easy we can develop and maintain a system

-System management complexity = issues like installing, configuring, detecting, recovering etc.

The complexity model is related to quality model. For example quality in use has close relationship with Business domain complexity

4 Evaluation and benchmarking of autonomic systems

Set of metrics
- Quality of Service (QOS)
- Cost
- Granularity/flexibility
- Robustness
- Degree of autonomy
- Adaptivity
- Reaction time
- Sensitivity
- Stabilization

IBM's software tool
- Security management
- User and resource provisioning
- Performance and capacity management
- Solution deployment
- Availability
- Problem management

=> Basic => Managed => Predictive => Adaptive => Autonomic

The set of metrics to evaluate and compare autonomic systems consist of:

Quality of Service (QOS), cost, granularity/flexibility, robustness, degree of autonomy, adaptivity, reaction time, sensitivity, and stabilization.

IBM has created an autonomic assessment software tool to measure the level of autonomic function against six operational areas within any I/T environment:

security management, user and resource provisioning, performance and capacity management, solution deployment, availability, and problem management.

IBM's tool analyzes an environment to determine its level of autonomic maturity: *Basic*, *Managed*, *Predictive*, *Adaptive* and finally *Autonomic* levels.

Benchmarking Autonomic capabilities 1(3)

- Traditional systems
  - Stable environment
  - Workload for typical use
- Results
  - How quickly the SUT process the workload

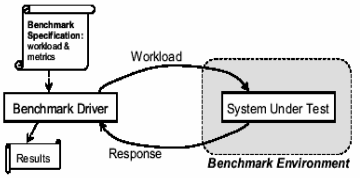


Figure 1(a). Traditional Performance Benchmark

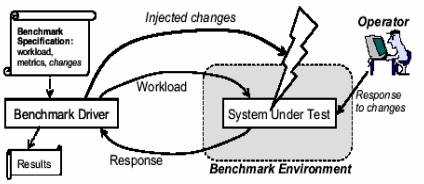


Figure 1(b). Benchmark for Autonomic Capability

A. Brown: **Benchmarking Autonomic Capabilities,** Conference on Autonomic Computing, 2005

Benchmarks provide a way to quantify progress in a field. One example is improvement of processor speed. IBM has studied benchmarking of autonomic systems covering autonomic capabilities: self-configuring, self-healing, self-optimizing, and self-protecting.

Traditional benchmarking of system performance

-A SUT is in a stable benchmark environment

-Benchmark driver give workload for SUT

-The SUT process that typical workload and send response to benchmark driver which calculate results (processing time)

Benchmarking Autonomic capabilities 2(3)

- Autonomic systems
  - Injected changes
  - Faults
  - Configuration changes
  - Simulated attacks
- Results
  - The level of response
  - The quality of response
  - The impact of response
  - The cost of extra resources

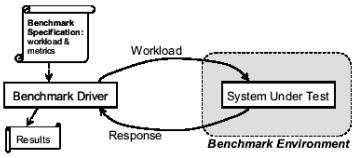


Figure 1(a). Traditional Performance Benchmark

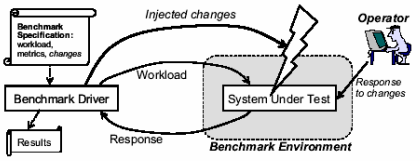


Figure 1(b). Benchmark for Autonomic Capability

Benchmark for Autonomic capacity

-Same kind of basic structure but now we must introduce change or changes into the stable environment

-faults into to the SUT to evaluate self-healing

-configuration change request to evaluate self-configuration

-Simulated attacks for self-protection

-Challenges

-How to ensure the reproduce of benchmark after changes

-Individual changes of SUT must be able to repeat

-In cross-systems comparisons changes must be repeated across different systems

-Results

-The level of response = how much human administrative support is still needed

-The quality of response = how well it execute the necessary adaptation

-The impact of response = the impact of the response on the systems users

-The cost of extra resources

Benchmarking Autonomic capabilities 3(3)

- Partially-autonomic systems
  - some autonomic capabilities
  - require some human support
    - system suggest a course of action
    - user's OK
  - Break the benchmark into separate phases
    - each phase scored individually
    - penalty (for example time) according to the amount of human support

Partially autonomic systems include some autonomic capabilities, but require some human administrative involvement. For example, a system might diagnose a problem and suggest an action, but wait for an administrator's OK before completing process.

One possible solution is to break the benchmark into separate phases such that human intervention is only required between phases. Each phase would be scored individually, with a penalty

applied according to the amount of inter-phase human support needed (time or a more complex scoring scheme).

5 Co-operation and markets

- Forums (SDR, UMTS, QoS etc)
- Working groups (3GPP, NGN Focus Group etc)
- Standardization organizations (ITU-T, ETSI, IETF)

⇒Recommendations, standards etc

⇒Co-operation in competing environment

Standardization

ITU-T, ETSI, IETF

Electronic Payment

EPF Electronic Payments Forum, OpenCard, RosettaNet

M-Commerce

MeT Mobile Electronic, MOBEY Forum, PayCircle, ECBS European Committee for Banking Standards

Internet-IP

INTERNET2 Internet2 Consortium, IPDR IPDR.org Initiative, RIPE Réseaux IP Européens, W3C World Wide Web Consortium

Internet-IP/Protocols

IPv6FORUM, MPLS MPLS and Frame Relay Alliance

2-4G

GSMA, OMA Open Mobile Alliance, UMTS Forum, 4Gmobile Forum

SDR Forum

QoS FORUM

NGN Focus Group

3GPP

6 Conclusions

- Prototypes to demonstrate increasing capability for self-management
  - from partial solutions towards systems
- Cooperative endeavor is needed
  - competition of markets
- Business models
  - development of legacy systems
  - building of new systems
- Human-computer interface

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