

WHITESTEIN
Technologies

Software Agent Technologies for Next Generation Autonomic
Communication and Networking

The Future Internet Research and Experimentation Workshop

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Objectives & Agenda



Overview

- ❑ Short introduction to Whitestein Technologies
- ❑ Next generation Autonomic Communication and Networking, ng-ACN
- ❑ How can software agents help?
- ❑ Real-world autonomic agent-based solutions for ng-ACN
 - Living Systems®Technology Suite - LS/TS
 - Living Systems®Adaptive Service Access Management suite - LS/ASAM
- ❑ Conclusions & Questions



Short Introduction to Whitestein Technologies

About Us



Our Mission

- ❑ Our mission is to be a world-wide leading provider of *advanced software agent technologies and autonomic solutions* for select application domains and industries.

Our Credo

- ❑ Whitestein Technologies strongly believes that *agent-based autonomic computing and communications*, in combination with other leading-edge technologies like *service-oriented architectures, grid computing, and mobile wireless communication*, enable attractive opportunities for the design and implementation of *next-generation information systems and network infrastructures*.

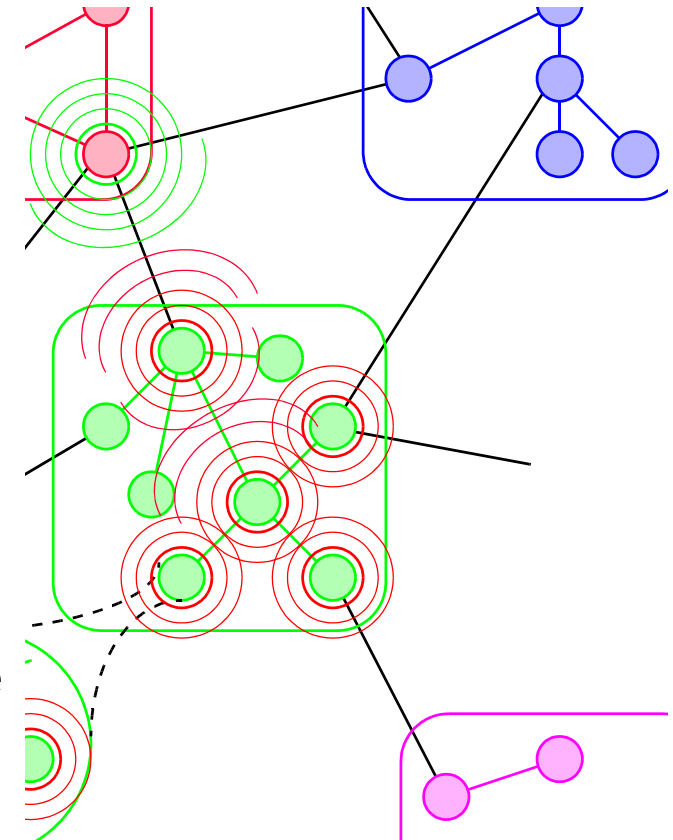
Company Settings

- ❑ An international Swiss-based SME founded in 1999
- ❑ A highly qualified and motivated staff of 80+ people at three locations in Zurich (Switzerland), Bratislava (Slovak Republic), and Donaueschingen (Germany)

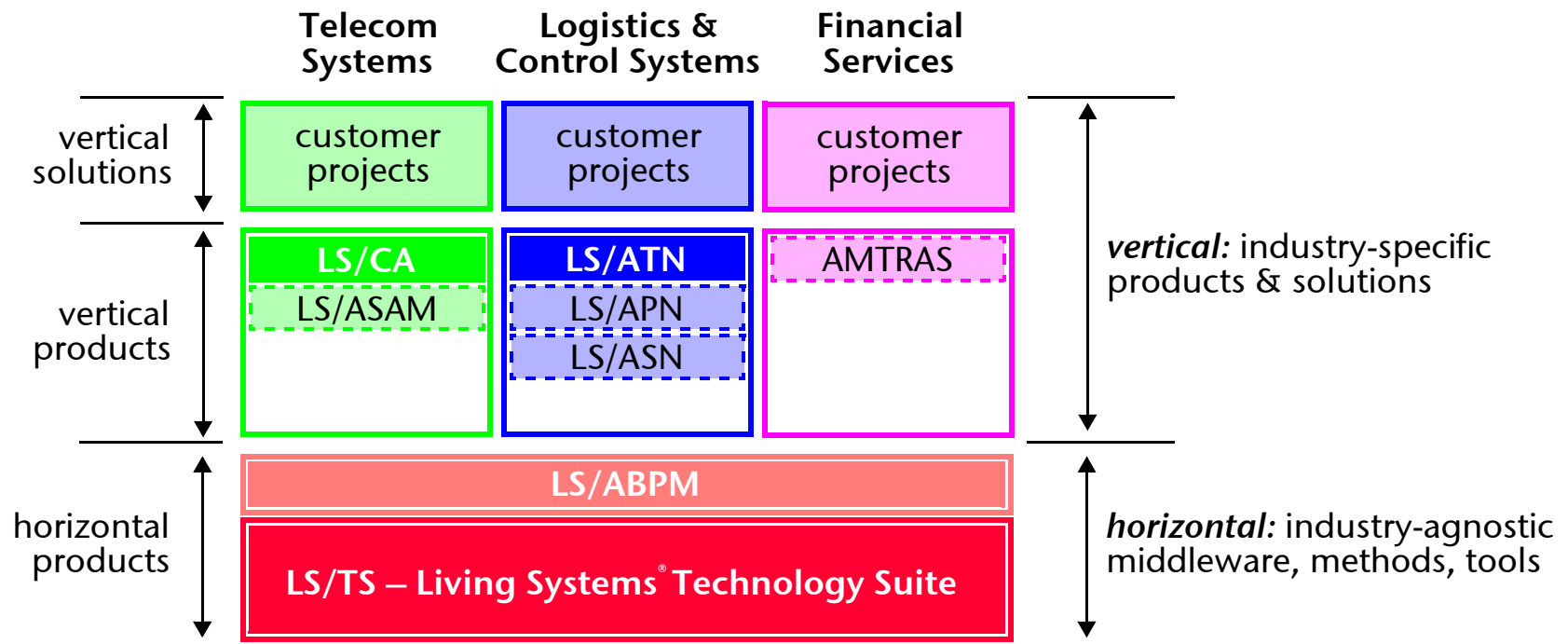


Why Software Agent Technologies?

- ❑ Increasing complexity and dynamics of business, technical, and human cooperation networks are demanding for a *new kind of computer systems and software applications*
 - Cooperation of autonomous, networked components instead of a centralized approach
 - Run-time-determined behavior instead of design-time-contracted behavior
 - Continuous real-time plan & execute instead of plan-then-execute
- ❑ *Software agent technologies & methodologies* possess the needed characteristics - in combination with other leading edge technologies
- ❑ *Whitestein's business focus:* software agent paradigm is the foundation for *industry-specific solutions* for different industries and application areas



Market Focus, Products & Services



plus: professional services (customizing, integration, consulting, support, training)



Next Generation Autonomic Communication and Networking

Next Generation Networking

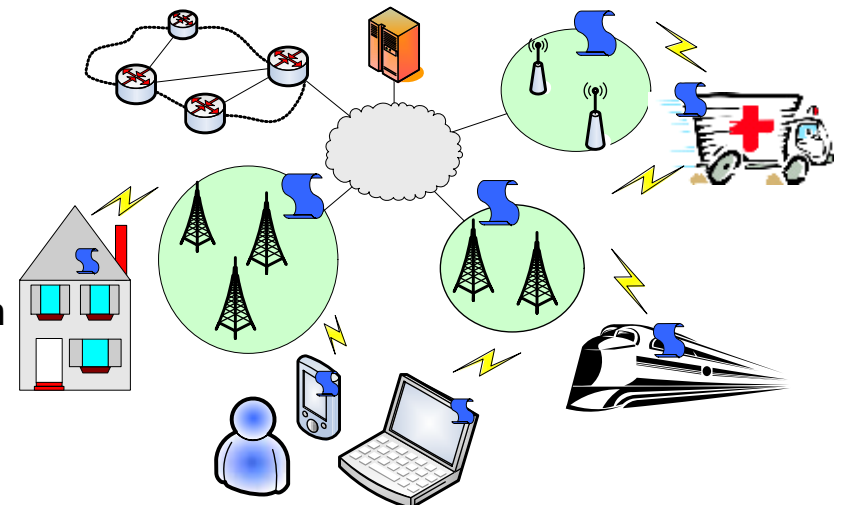


The Next Generation Networks vision

Next Generation Networks are becoming increasingly *open*, commonly *shared* relying on highly *distributed components* to deliver *mobility, personalization, transparency* and *immediacy*. *Broadband access from and to anywhere* is creating a new dimension for both business and consumer customers, which is modifying computing, travel and transport environments.

Managing complexity as the key issue

- ❑ Increasingly demanding users
- ❑ Advanced smart devices enabling a variety of multimodal deployment scenarios
- ❑ Proliferation of applications, services and heterogeneous technologies
- ❑ Increasing number of players - high competition
- ❑ Increased business complexity





The challenge

Operators and service providers need to enable the delivery of new, easy-to-use, context-sensitive and reliable services, while lowering operational costs, by optimizing the way in which network performance and resources availability are managed.

Most of the traditional...

- ❑ *Client-server solutions* are neither very effective nor entirely appropriate to handle the increasing dynamicity and diversity of heterogeneous network technologies & services

A new kind of approach to manage and control network and services is needed:

- ❑ A comprehensive *policy-driven, autonomic* solution spanning provider infrastructure and end user devices, which builds adaptive control directly into the respective elements
 - *Autonomic* in the sense of pushing the burden of many support and control tasks from users to the underlying solution components *to assist, facilitate and empower human decision making* according to specific business goals and policies



Autonomic Communication & Networking, ACN, as the provisioning of:

Network management and control systems embedding *self-management capabilities* at the core of their functioning to increase reliability and performance while reducing operational and management costs.

These capabilities include:

- ❑ **Self-configuration** or capability of automatically changing the operating system parameters to adapt to mutable external conditions, some of which may even be unknown at system design time
- ❑ **Self-healing** or ability to detect and repair unforeseen malfunctions, by autonomously attempting to determine compensation actions and then performing them
- ❑ **Self-optimization** in the sense of continuous assessment of the performance, exploring possible improvements and adopting courses of actions aiming in that direction
- ❑ **Self-protection** intended as the capability of detecting threats against the system itself and triggering preventive and/or corrective measures to ensure correct functioning despite these threats



Autonomic computing principles applied to networking

- ❑ Bringing *increased intelligence into the networking context* (at various levels) in order to:
 - *Client perspective*: better serve end-users by hiding low-level technical service access and deployment issues while dynamically adapting to the specific context and usage requirements
 - *Network perspective*: manage business, service and network complexity by performing time-consuming tasks on behalf of human operators (e.g., network administrators) supporting and enabling them to focus on higher-level tasks
- ❑ A next generation ACN, ng-ACN, system must exhibit specific capabilities:
 - *Self-awareness*, i.e., be aware of its internal state
 - *Context-awareness*, i.e., be aware of external current operating conditions
 - *Self-monitoring*, i.e., be able to monitor and detect changing circumstances
 - *Self-governing*, i.e., be able to follow specific policies to oversee and govern its behavior



An evolutionary perspective

Is there something revolutionary about adding automation and adaptation as a means of simplifying network management and control?

- ❑ Not really... (luckily) thinking for instance of the TCP control loop for adjusting its congestion window or of many intrinsic today's routers self-controlled traffic engineering mechanisms. So what is new?
- ❑ *Innovation* lies on the way the *feedback control loop* enabling a network or a system to govern and adapt its behavior is engineered:
 - A *base system*, which provides concrete functionality required to meet the system design goals
 - Business goals as explicit system's input, i.e., part of the system
 - An *autonomic controller*, which monitors both the base system and the external environment, decides and enacts self-management policies
 - Increased self-* capabilities as answer to increased complexity



How Can Software Agents Help?

How Can Software Agents Help?



In essence to...

... cope with key requirements of dynamic ng-ACN scenarios by making it possible to:

- ❑ Flexibly extend functionality of existing network management and control systems
- ❑ Support an effective orchestration and deployment of emerging services
- ❑ Provide advanced and innovative solutions for upcoming ng-ACN architectures

The agent choice understood as:

- ❑ A comprehensive approach to model and build software and not just a “technology”
- ❑ *Software agents* conceived as *configurable, distributed software components* that:
 - Assume *role-based* business responsibilities
 - Aim to achieve *given business goals*, following *specific policies and plans*
 - *Autonomously* work (own thread of control) *on behalf* of and/or *represent* their owners
 - Can *communicate* in order to coordinate and cooperate (asynchronous messages)

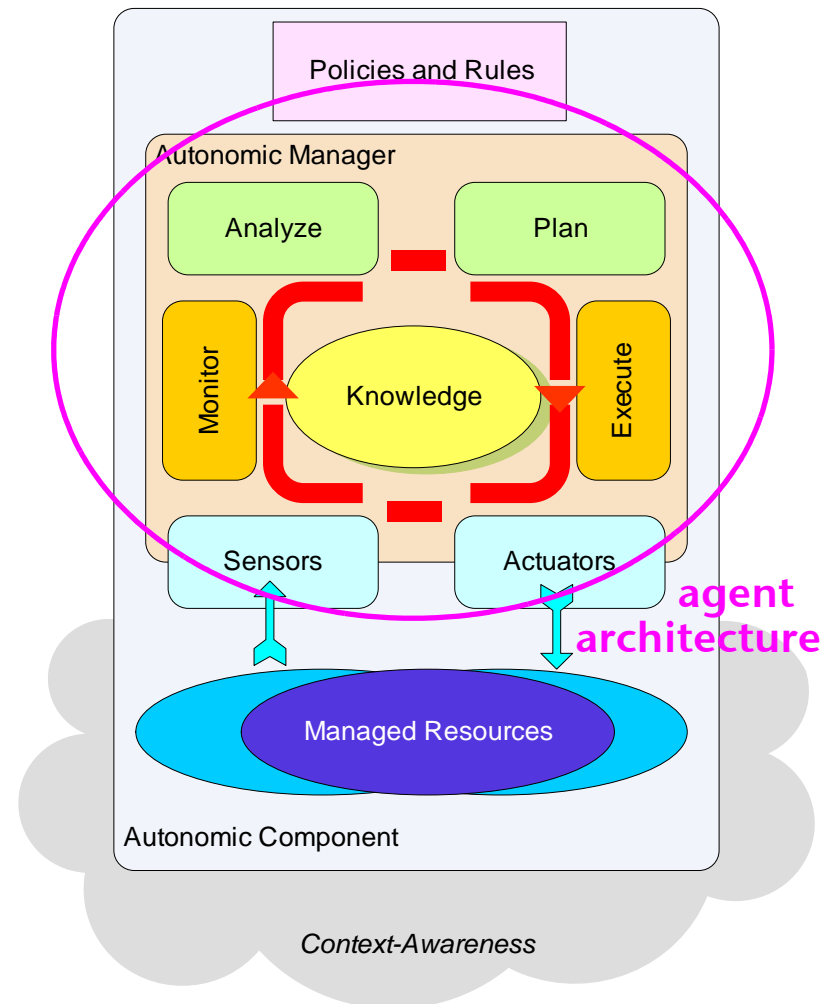
How Can Software Agents Help? (cont.)



Autonomous agent: the locus of autonomic self-management capabilities

Loosely-coupled distributed communication and networking functions well-modeled and implemented by means of *autonomic*, *goal-driven* and *proactive* software agents that according to the results of changes in the context that they are embedded are able to:

- ❑ Operate on various devices/network elements and support asynchronous communication with intermittent network connections
- ❑ Assist with the speed-up and automation of several service management & control tasks traditionally performed by humans
- ❑ Configure themselves and dynamically optimize their operations according to changes in the environment and in-line with specific policies



How Can Software Agents Help? (cont.)



Agents for managing complexity, dynamics, and distribution of ng-ACN

Application area	Description
<i>Network design & planning</i>	Agent systems can be run “off-line” to <i>simulate the future network behavior</i> based on given events (e.g., traffic overload, network failures) and/or different boundary conditions (e.g., different network topologies, capacity) as a basis for <i>more effective network planning, design, and performance optimization</i> .
<i>Network monitoring and control</i>	Autonomic monitoring, fault-detection, diagnosis and recovery, decision preparation, coordination, and (re-)configuration to <i>lower workload of repetitive operations</i> giving more time to humans for core tasks and responsibilities.
<i>Resource management</i>	Autonomic, distributed, communicating and possibly negotiating agents enabling <i>resource allocation to be locally optimized and globally coordinated</i> . <i>Decentralized and autonomic bottom-up optimization</i> instead of centralized top-down optimization, at run-time and in real-time.
<i>Context-aware & seamless service provisioning</i>	<i>Facilitate the dynamic aggregation of services</i> according to the specific context agents sense and effect on by controlling and <i>hiding low-level technical operations in a user-centric perspective</i> -> seamless service provisioning
<i>Business Process Management</i>	Goal-driven agents to govern and implement business & operation processes by mapping business needs to ICT services in a more automated and dynamic fashion, and thereby enabling true end-to-end service delivery chains.



Real-World Autonomic Agent-Based Solutions for ng-ACN



A comprehensive agent middleware and development environment

LS/TS is an industry-grade, Java-based foundation for the professional development and operations of products and solutions based on software agent technology and autonomic computing including:

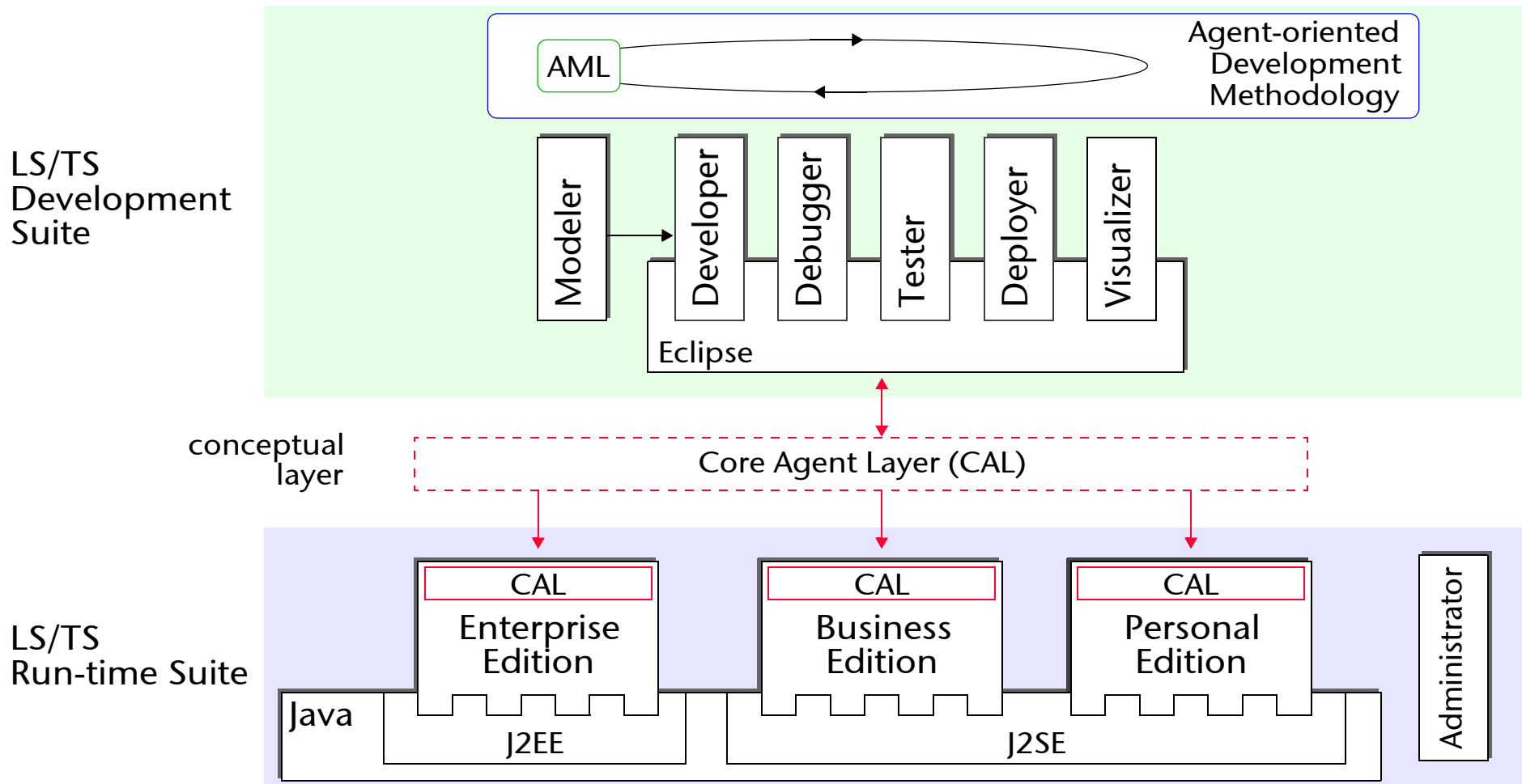


- ❑ ***Run-time suite*** (middleware)
 - Messages and states, resource management
 - Load-balancing through federation, fail-over through clustering, integration
- ❑ ***Development suite***
 - Development process, AML (based on UML 2.0), LS/TS Modeler
 - LS/TS Developer, LS/TS Debugger, LS/TS Tester, LS/TS Deployer
- ❑ ***CAL - Core Agent Layer***
 - Autonomous agent, execution engines, MDAL, goal-oriented behavior (BDI)
 - Asynchronous messaging, semantic communication, directory service, notifiicator

LS/TS - Living Systems® Technology Suite (cont.)



LS/TS Architecture





A comprehensive approach to engineer autonomic systems

- ❑ By separating application-independent features and subsystems to be reused across several applications LS/TS provides a *middleware approach to engineer autonomic computing*
- ❑ The *feedback control loop* mechanism enabling a network or a system to govern and adapt its behavior can be engineered in several ways by means of LS/TS
- ❑ The LS/TS Autonomous Agent “... represents a control element of the application logic, able to sense its surroundings, act on them and also to coordinate with other agents” [Rimassa et al., ICAS 2006].

This enables to realize the core properties required for ng-ACN systems given that in particular LS/TS autonomous agents are:

- *Self-aware*, meaning aware of their goals, capabilities and internal state
- *Context-aware*, that is able to understand external current operating conditions
- *Self-monitoring*, i.e., autonomously monitoring and detecting changes and events
- *Self-governing*, according to specific goals and policies to oversee their own behavior

Adaptive Service Access Management



LS/ASAM - Living Systems® Adaptive Service Access Management Suite

A comprehensive *autonomic middleware solution to effectively manage connectivity of nomadic end hosts across heterogeneous access networks, while optimizing the way network performance and resource availability are managed*, which includes:

- ❑ The *Living Systems Connection Agent*, LS/CA, a client component enabling:
 - Seamless mobility with adaptive connection handover across multiple technologies
 - Dynamic and automated mediation of service delivery parameters
 - Secure network access
- ❑ The *Living Systems Service Access Manager*, LS/SAM, a network component enabling:
 - Proactive monitoring and management of traffic and network conditions
 - Mediation between operator policies and end user requirements
 - Optimized resource allocation with adaptive problem recovery and load balancing

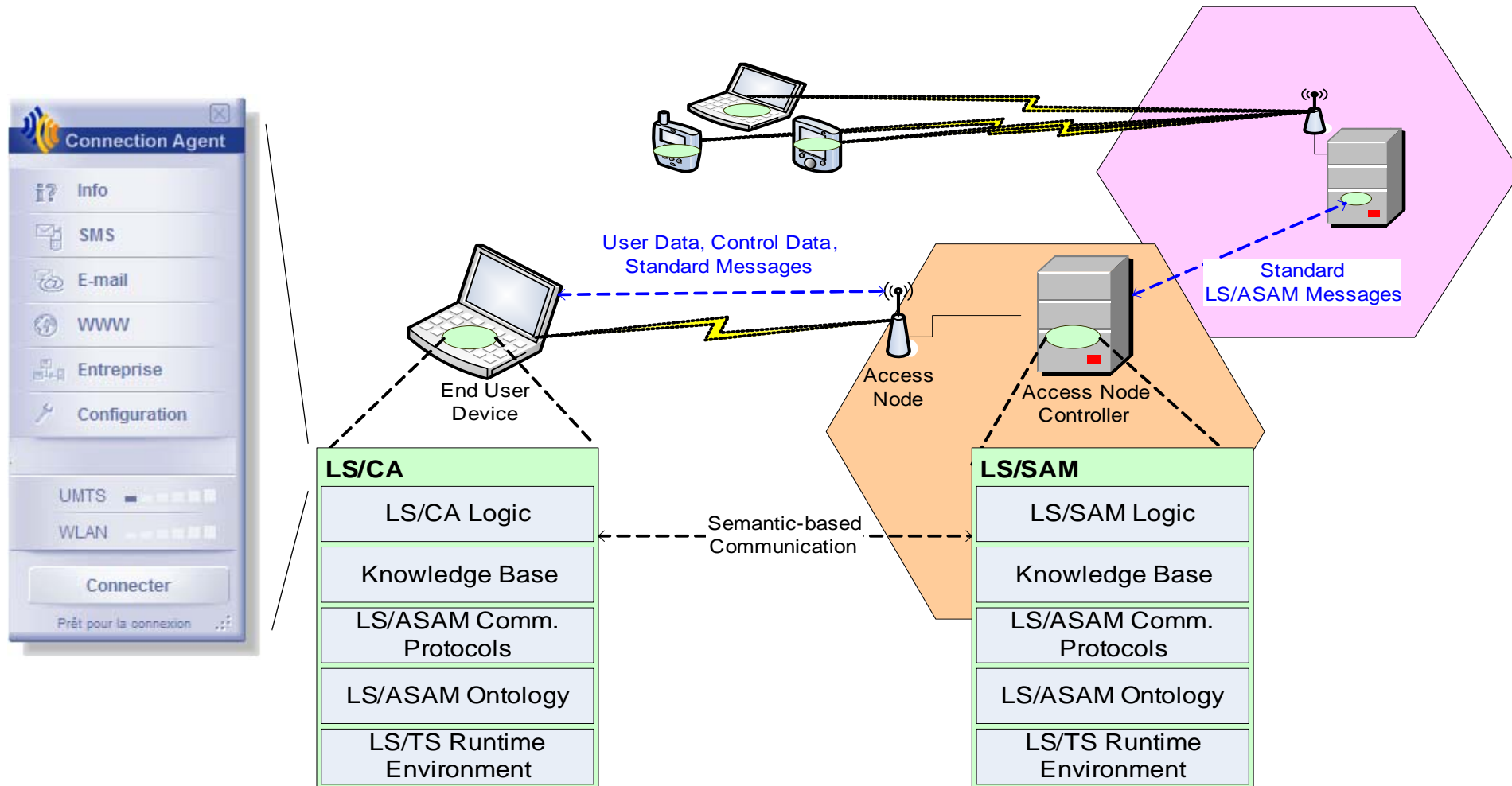




(cont.)



An overview of the LS/ASAM architecture



(cont.)



From adaptive to autonomic service access management

- ❑ LS/ASAM is a middleware solution exhibiting autonomic self-management capabilities:
 - **Self-configuration:** policy-based configuration of the LS/ASAM Suite components according to changes in their usage and working environment.
 - **Self-optimization:** proactive monitoring and control of resource usage, performance and end user experience to enforce optimal behavior.
 - **Self-healing:** automatic faults discovery and correction, both on the end user devices and network elements.
 - **Self-protection:** automatic detection of and protection from unauthorized system control changes.
- ❑ Control over the LS/ASAM autonomic components is expressed by means of policies that are bound to user preferences and business goals
- ❑ Dynamic mediation between the LS/CA and the LS/SAM enables the coordination of local versus global optimization efforts



Conclusions and Questions



How to realize the ng-ACN vision?

By transforming the architecture and functionality of the network by means of self-* capabilities

- **Key challenges** in line with *ICT 2007.1.1* and *ICT 2007.1.2* Objectives and the *FIRE* initiative
 - **“Do not touch my network!”** Populating networking environments with autonomic software components requires increased configuration and monitoring capabilities: how? Up to which limit?
 - **Adaptivity versus controllability.** Middleware is required to become able to monitor and control the middleware itself: how to guarantee proper functioning even if only limited and sometimes inconsistent information is available?
 - **It is all about context.** Understanding the context in a consistent way across multi-technology networks demands for a commonly shared semantics: is this enough? How in open dynamic environments? How to guarantee security?
 - **Global consistency.** How to resolve conflicts and guarantee global coordinated behavior of possibly self-interested autonomic components? Which architecture? How to scale?

Conclusions (cont.)



Software agents as key ingredients for ng-ACN

- ❑ NGN are pressing for more dynamic and flexible ICT solutions able to:
 - **Adapt**, when circumstances change, their behavior by means of learning capabilities, continuous monitoring of the environment, reactive and proactive actions
 - **Personalize** offered services so that they better fit to particular people, place, times and events by acquiring and making use of context-relevant information
- ❑ **Agent technology** provides powerful metaphors, concepts and techniques *for conceptualizing, designing and implementing ng-ACN solutions*:
 - Agents providing built-in **distribution, adaptability** and **sociability** (cooperation)
 - Agents as **smart decision making** support components in complex NGN scenarios
 - Agents for **self-managed delegation of work load** by performing tasks that would be otherwise very difficult, time consuming, costly or just infeasible for humans





Summary

- ❑ Whitestein Technologies' *real-world experience* confirms that software agents cope with key requirements of dynamic ng-ACN scenarios by making it possible to:
 - Flexibly extend functionality of existing network management and control systems
 - Support an effective orchestration and deployment of emerging services
 - Provide advanced and innovative solutions for upcoming ng-ACN architectures
 - ❑ ... but only when addressing major challenges:
 - Providing solid methodologies, platforms, tools and products for industrial-grade development and deployment of agent technology
 - Facilitating the understanding and integration of agent technology in close combination with specific application-driven business requirements
 - Taking into account dynamics of NGN and increasing variety of technologies
- *EU-based R&D collaboration as key for Whitestein Technologies to meet these challenges*

Conclusions (cont.)



Any question?

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Acknowledgments

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