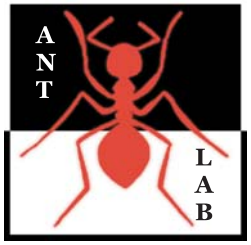
Politecnico di Milano

Advanced **N**etwork **T**echnologies **Lab**oratory



From a world of small smart objects to the big new Internet

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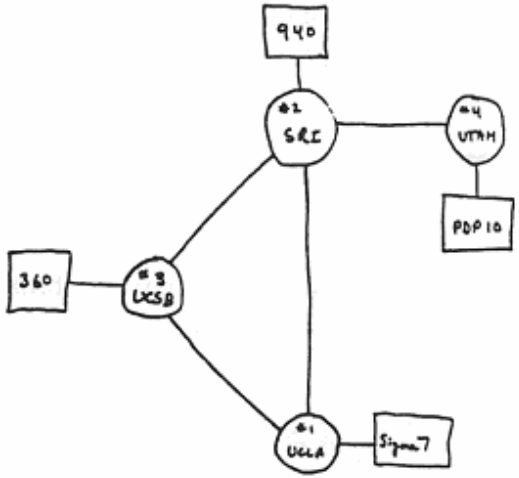
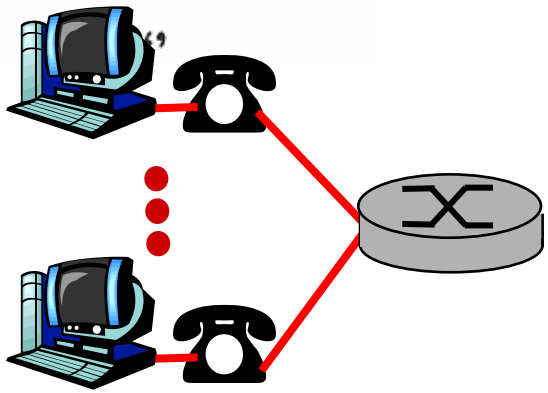
Where everything started

Internet:

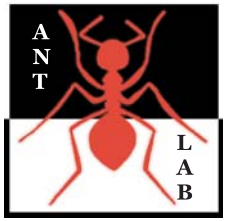
- Started out as research network running on top of PSTN
- Was an "overlay" that complemented the basic PSTN infrastructure by adding new functionality (PSDN) to support special needs as P-to-P computer communications



THE ARPA NETWORK



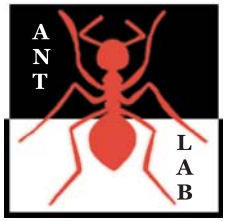
Where everything started



… continued

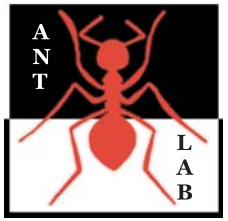
- Has evolved into the principal platform for global public communications infrastructure
- IP packet transport provides basic transport medium for multimedia applications
- Success due to interoperability and connectivity supported by IP protocols and e-2-e design principles
- From an "overlay" application to basic infrastructure

Problems due to success



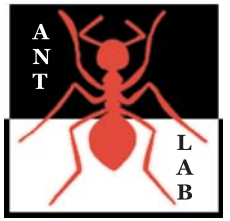
- Heterogeneous services
  - different capabilities
- New needs and requirements
  - real-time services
  - enhanced security
  - Multicast, anycast, multipoint-to-multipoint
- Complexity and size issues
  - magnitude of traffic
  - connectivity

Solution (?)



- Continue evolution
- Internet is now spawning its own collection of "overlay" networks
  - Peer–to-Peer
  - Content-Delivery
  - Content based Routing
  - Security
  - Experimental
  - …

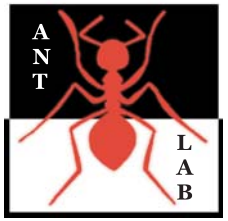
Solution (?)



Questions:

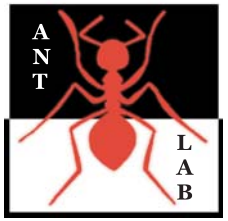
- Are "overlays" precursors to the future Internet architecture?
- Are "overlays" patches on the Internet that threaten the e-2-e connectivity and interoperability?

Why do overlays emerge?



- To support special requirements of particular class of applications or user community. Which functions are basic or specialized?
- To help the dynamic evolution of Internet technology
  - new routing,
  - new architecture designs
  - incremental deploy of new solutions
- To accommodate conflicts among heterogeneous interests
  - a struggle between and among customer, service providers and policy-makers
- Overlays will remain an important and growing feature of the Internet landscape

… however



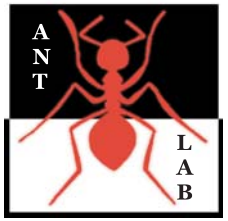
Sensor Networks …

Wireless Sensor Networks …

Wireless Sensor and Actor Networks!

- next step of an application evolution path
- intelligent actor devices take decisions in a distributed way based on the information provided by sensors.

Sensor networks today

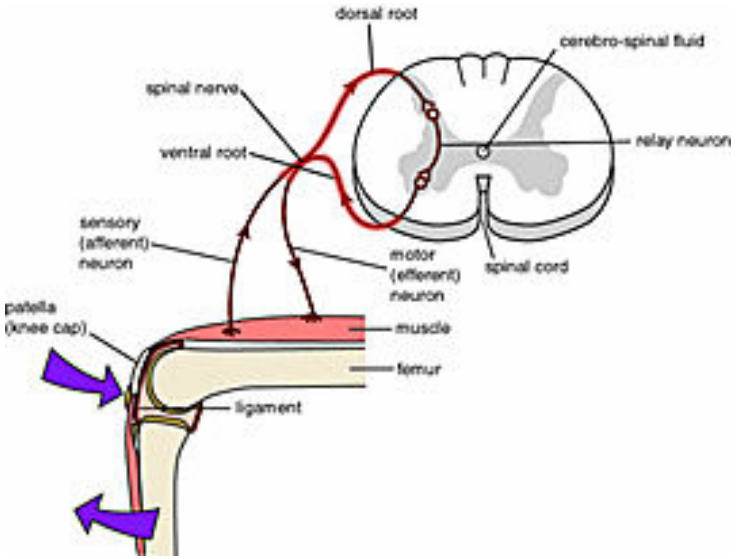


- Large number of static sensor nodes
- deployed in harsh environments
- devoted to the sensing and communication needs of a specific application scenario
- the system as an autonomous entity
- deployed on the area to be monitored,
- based on a single wireless technology
- sensing and communication functions vertically integrated to meet the requirement of the specific application

A world of small smart objects

- New multi-purpose sensor-actor system
- The system can dynamically self-organize, self-manage and self-optimize
- Heterogeneous needs of multiple applications built over it
- Devices will be interconnected through a network
  - Local connectivity (WSAN)
  - Large scale interconnection
- Decisions of actions to be performed will be taken by intelligent control agents in a distributed way
- Sensors and actuators will remotely controlled by human operators.

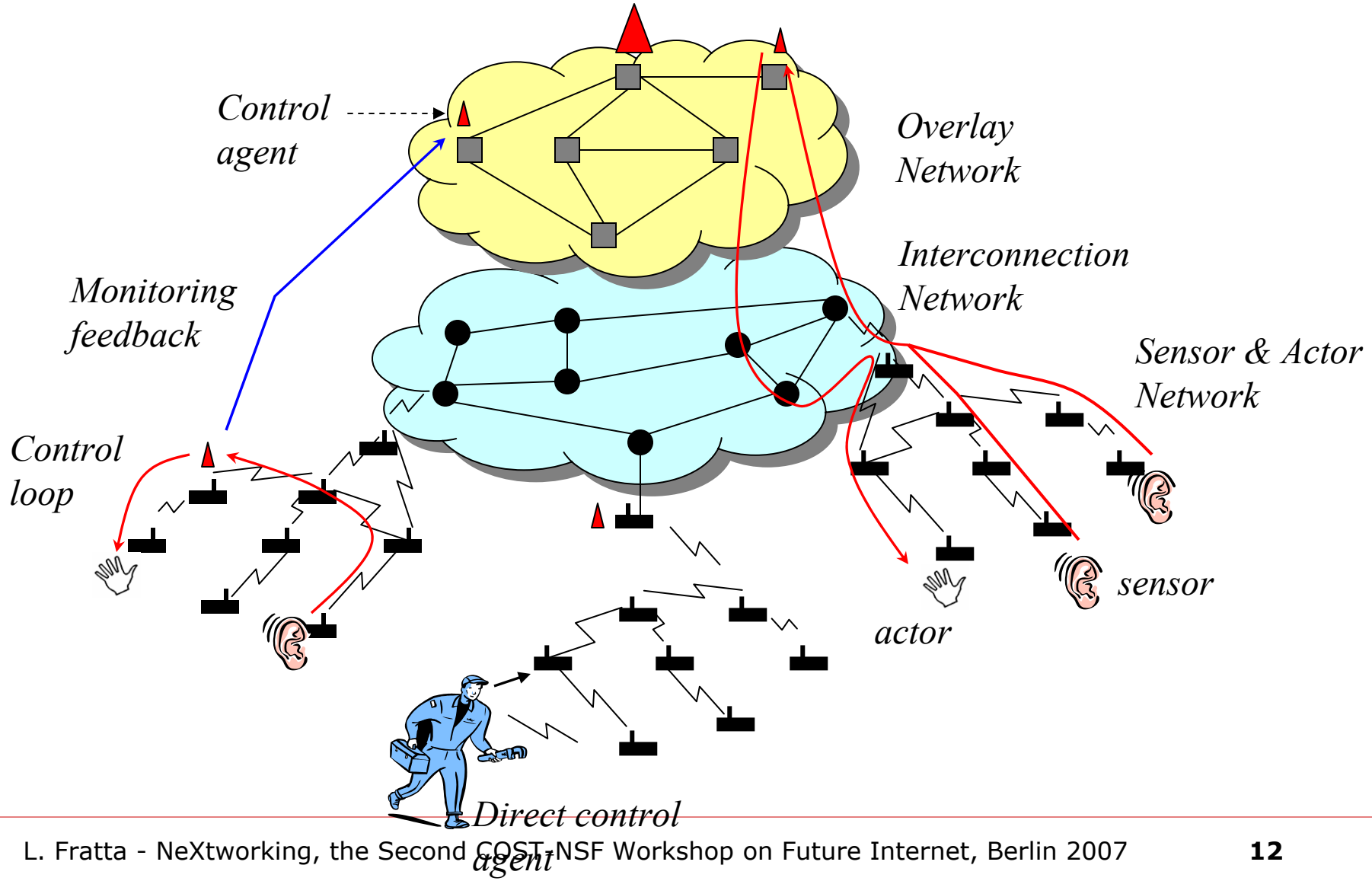
Reflex action in a biological control system



- Stimulus is processed in the spinal cord and an immediate response is created
- The sensation is also transmitted to the brain which would process a more cognitive evaluation of the situation

- A mixed distributed and centralized scheme
- Key element in the design large and complex sensor and actuator networks
- … and make them available to a large set of control applications.

A world of small smart objects

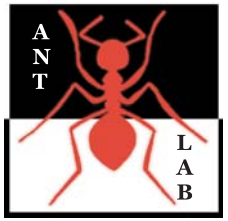


Challenges

- The resulting network architecture poses new challenges mainly due to:
  - the critical performance required
  - the distributed control
  - the coordination algorithms among actors.

- Distributed monitoring
  - Continuous monitoring for scanning the system and evaluating possible actions
  - multi-point to multi-point communication mode (e.g. publish-subscribe system)
- Creation of a control process
  - Find in the network computation and communication resources to start an action
  - Assign roles to devices
- Continuous control
  - Real-time communications between control agents, sensors, actors, higher layer controllers

The Internet of the Future

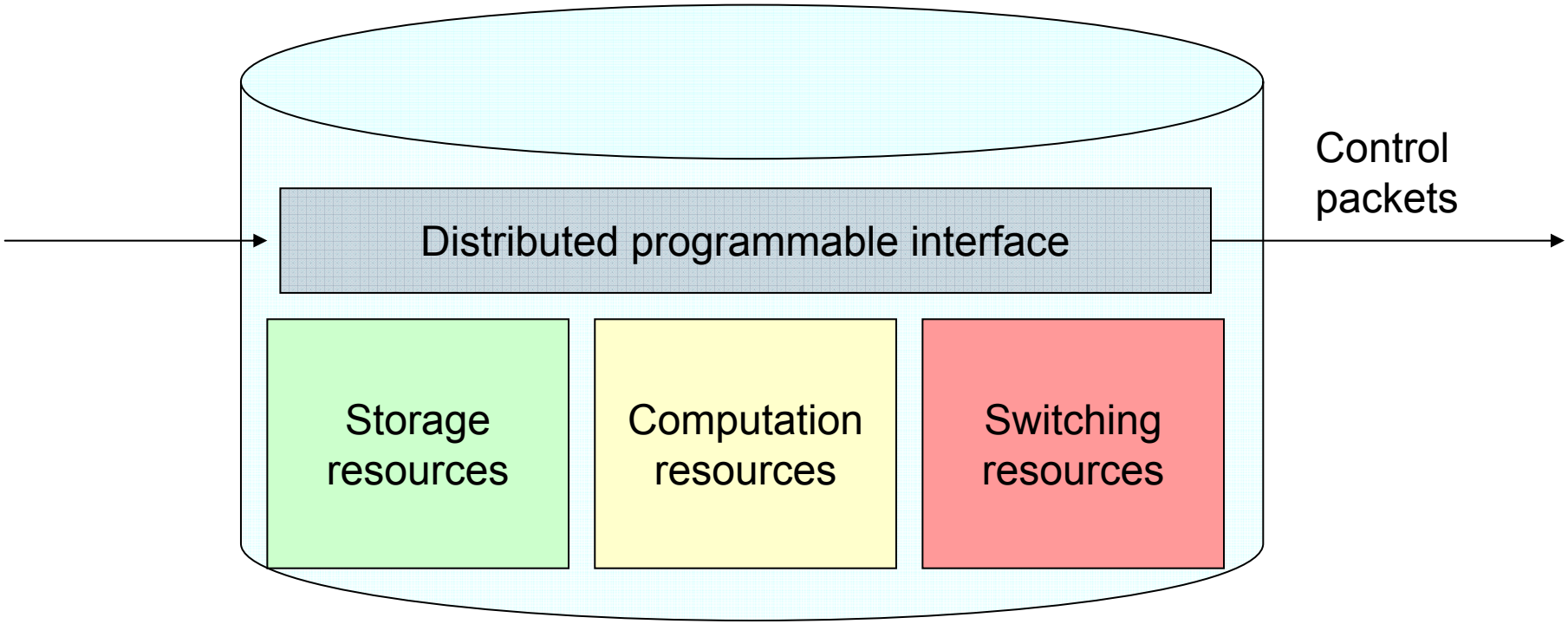


- Applications are no longer confined in the network edges and are entering in the network
- Is the overlay approach the most appropriate to support the huge number of applications running in the network?
- Can we provide support to applications at the network layer?
- Can we address packets to applications rather than to hosts?

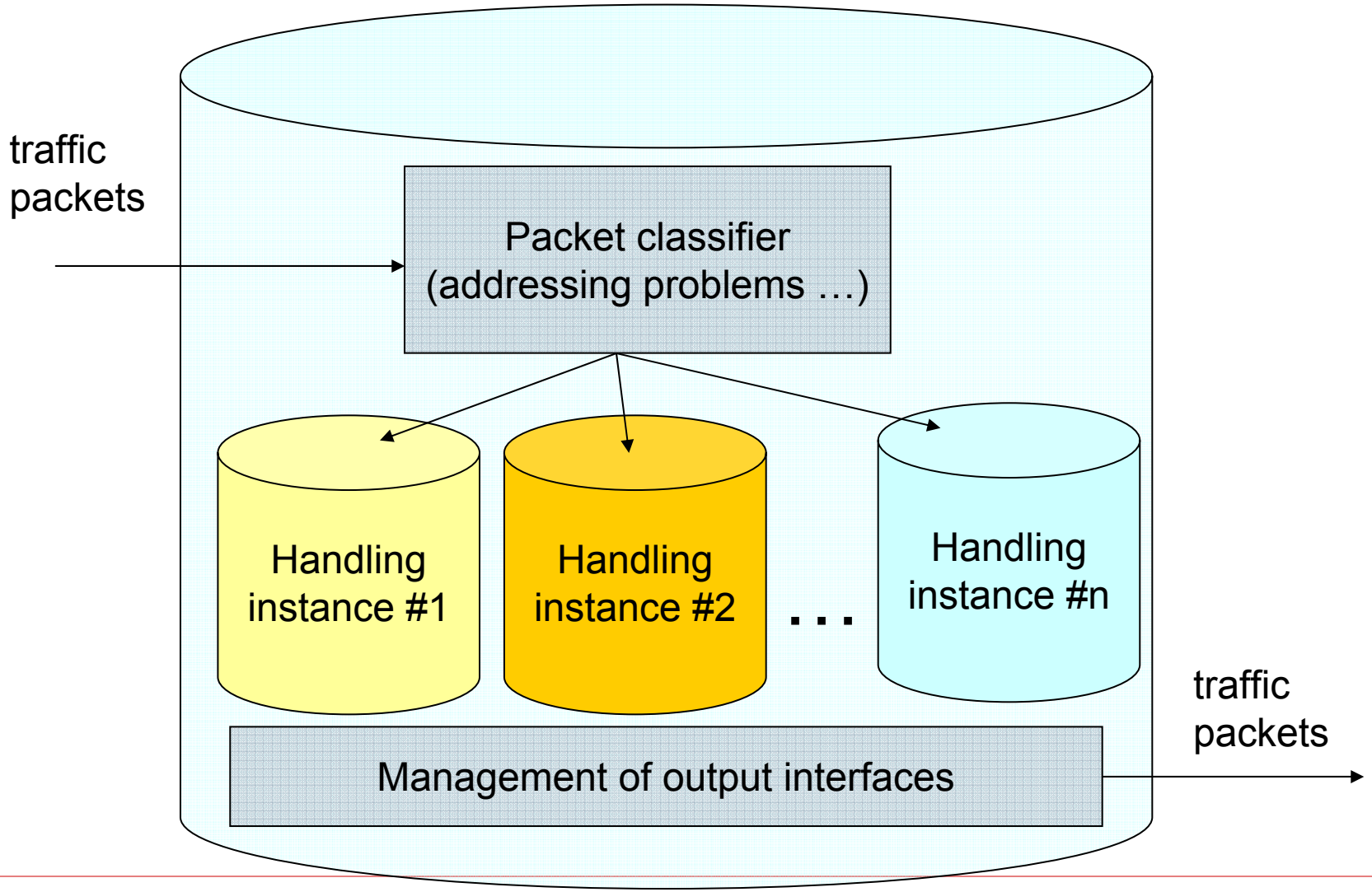
➔ New communication paradigms (multipoint-to-multipoint, anycast, etc.)

➔ Computation resources in network nodes (data elaboration/aggregation, distributed control functions, etc.)

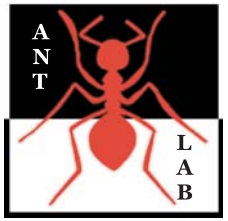
New network devices



New network devices



Conclusion



- Flexible addressing mechanisms (addresses, names, identifiers, …)
- New basic communication methods available at network layer (point-to-multipoint, point-to-any, multipoint-to-multipoint)
- Advanced communication methods available on demand (class based routing, data aggregation, etc.)
- Computation and storage resources available for meeting distributed application needs
- Security mechanisms for managing access to resources