Privacy and Anonymity in Personal Networks

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Outline

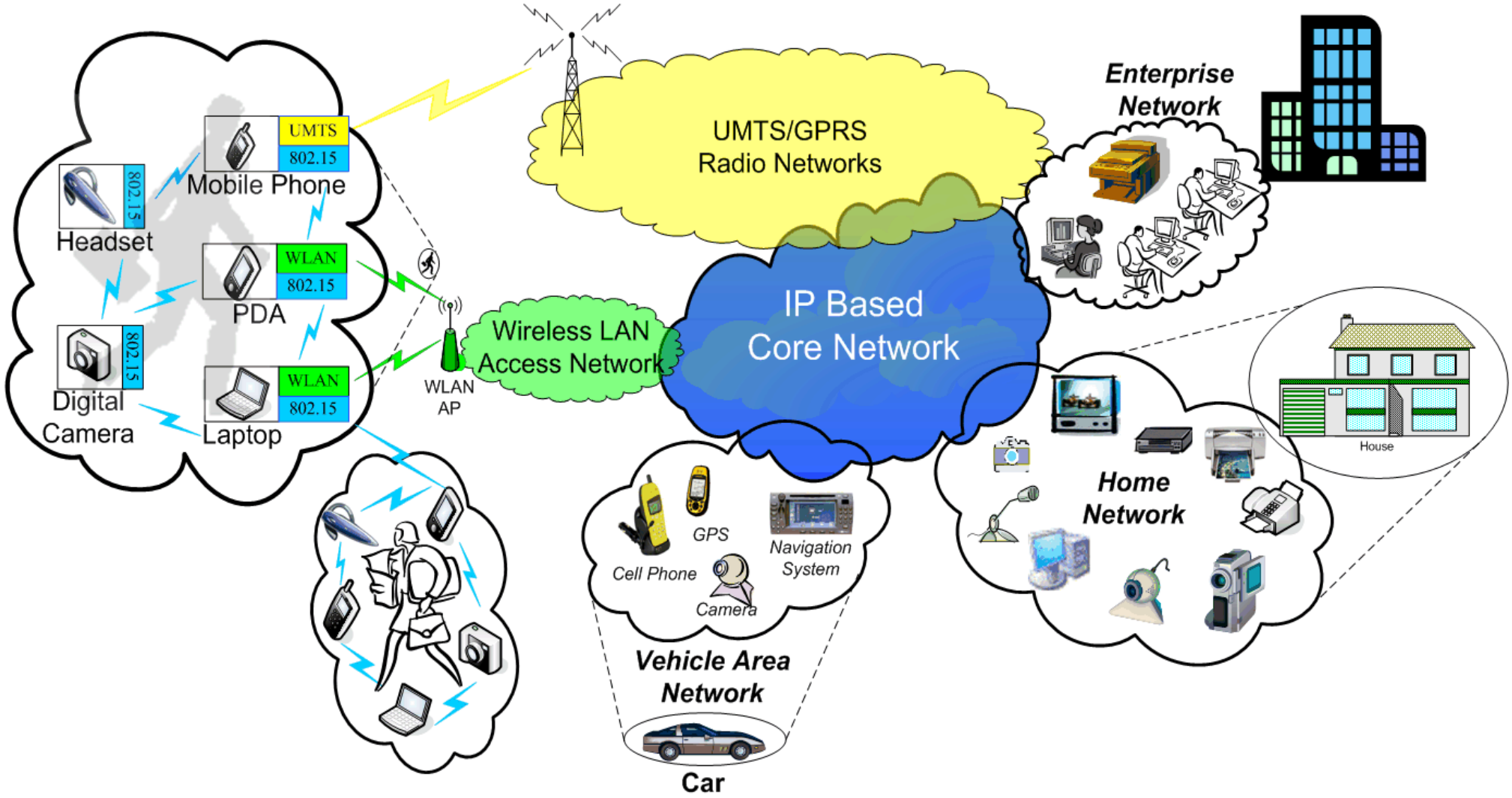
- Introduction to Personal Networks (PN)
- The proposed PN architecture
- Security implications of the architecture
- A possible implementation
- Conclusions

Introduction to Personal Networks (PN)

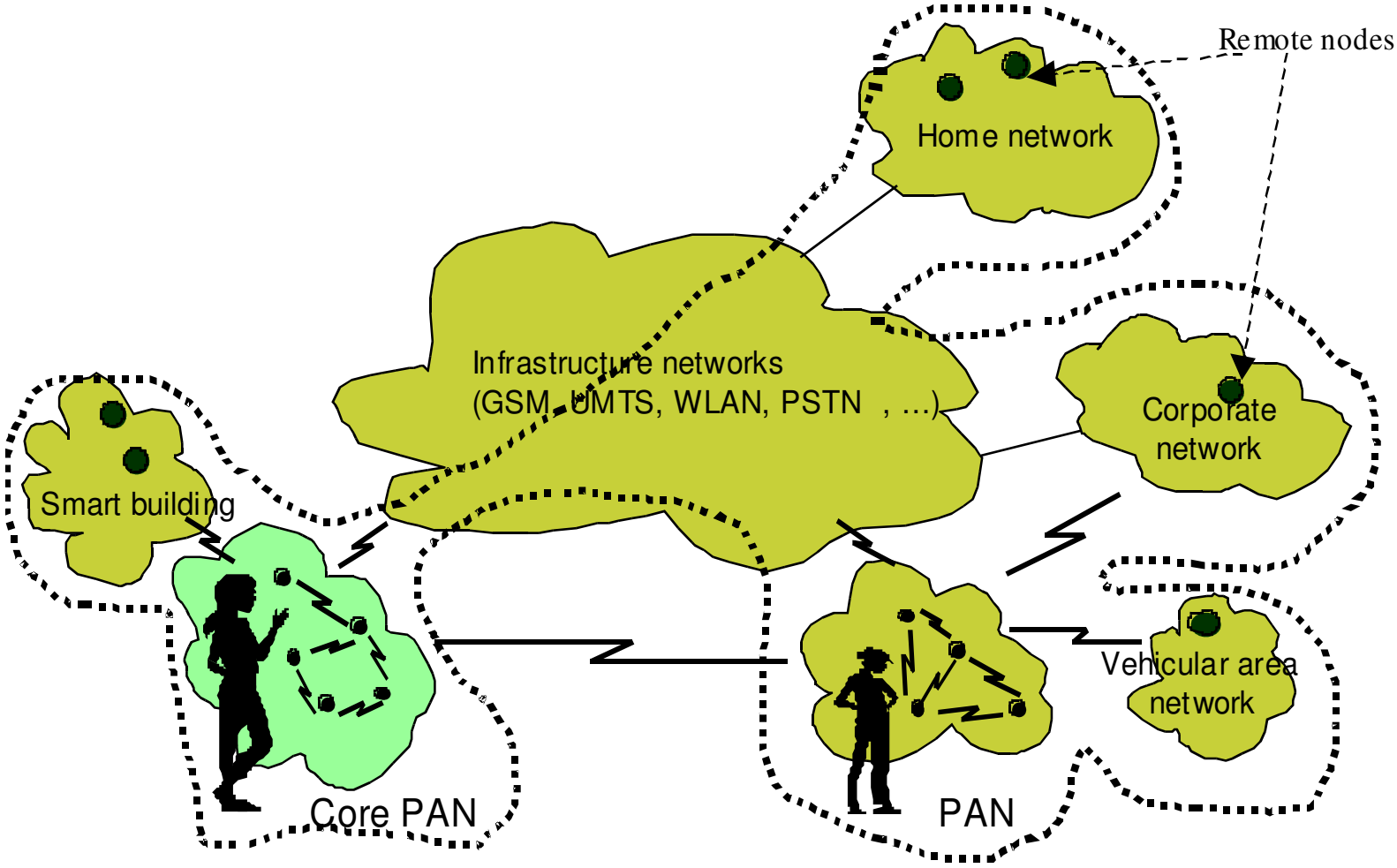
From PANs to Personal Networks

- Personal Area Network (PAN)
  - Network consisting of personal devices in the close vicinity of the person (Personal Operating Space or POS)
- Personal Network (PN)
  - Network centered around a person and his/her needs
  - Resources and devices are not necessarily in the close vicinity of the person
  - Dynamic in composition, configuration and connectivity depending on time, place and circumstances
  - Core consisting of a PAN extended with personal resources or resources belonging to others.

An example of a PN



Abstract PN view



From: I.G. Niemegeers and S.M. Heemstra de Groot,

"Research Issues in Ad-Hoc Distributed Personal Networking",

Journal on Wireless Personal Communication, Kluwer, Vol. 26, No. 2-3, 2003, pp. 149-167

Composition of a PN

- A Private-PAN (P-PAN) around a person consisting of local personal devices and services
- Remote personal devices and services

- Local foreign devices and services
- Remote foreign devices and services
- Interconnecting structures

The proposed PN architecture

The Personal Identifier (PID)

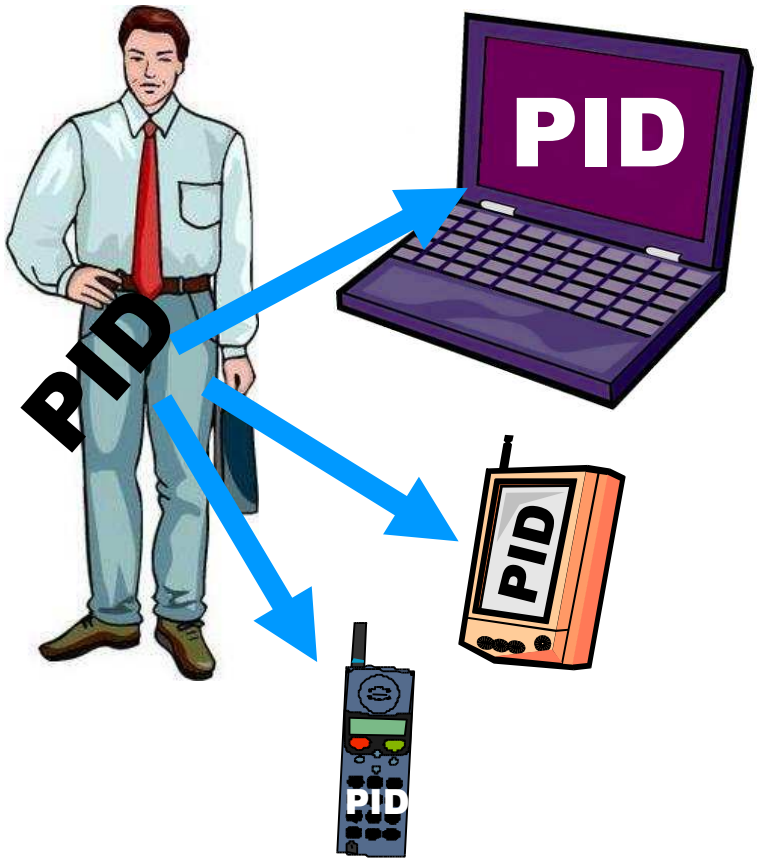
PID is:

- An abstract concept – a security policy model
- About trust relationships between Nodes
- PID models ownership – ease of use

PID is NOT:

- An implementation or implementation design!

Personalization of Nodes

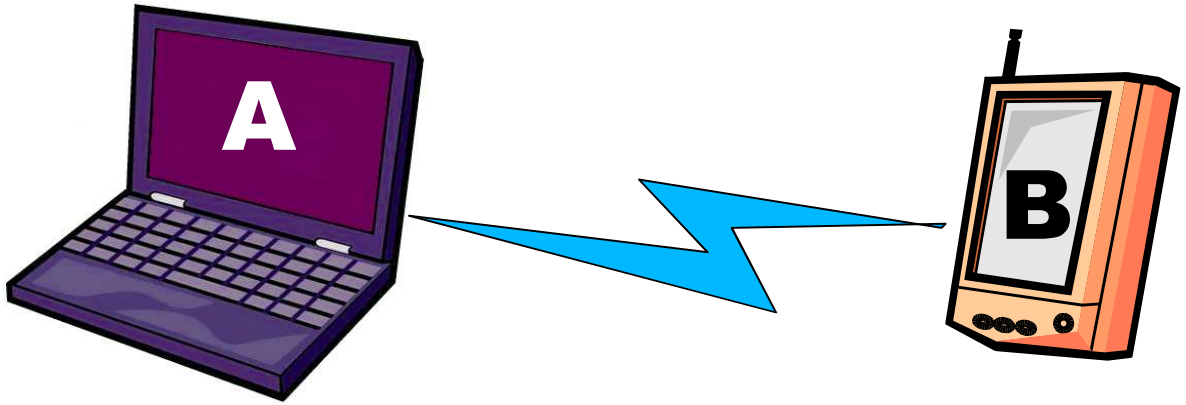


How can the PID be entered:

- Using the keyboard
- Upload it from another Node:
  - Cables
  - Near Field Communication (NFC)
- Removable media
- SIM-card

Personal Identifier (PID) may be some kind of secret key

When one Node meets another Node



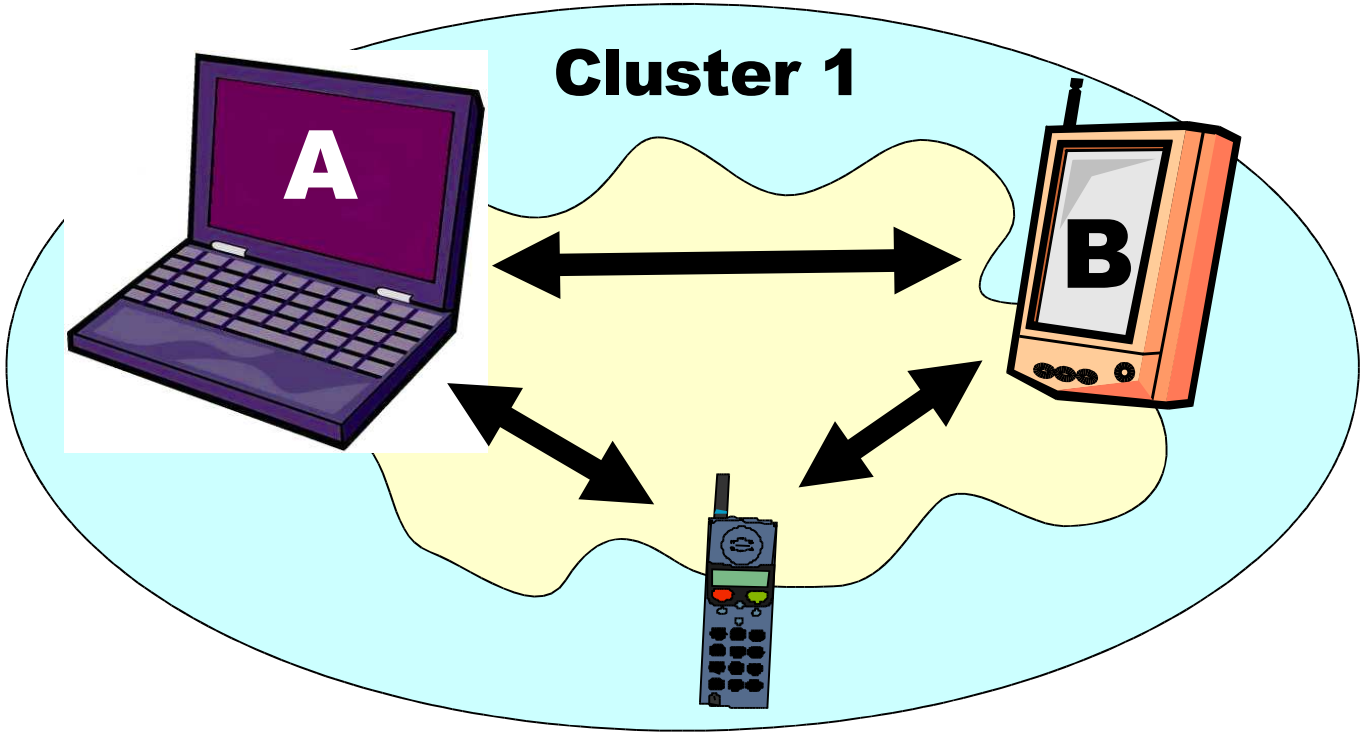
$\{Hello, A\}_{PID}$ →

$\{Hello, B\}_{PID}$ ←

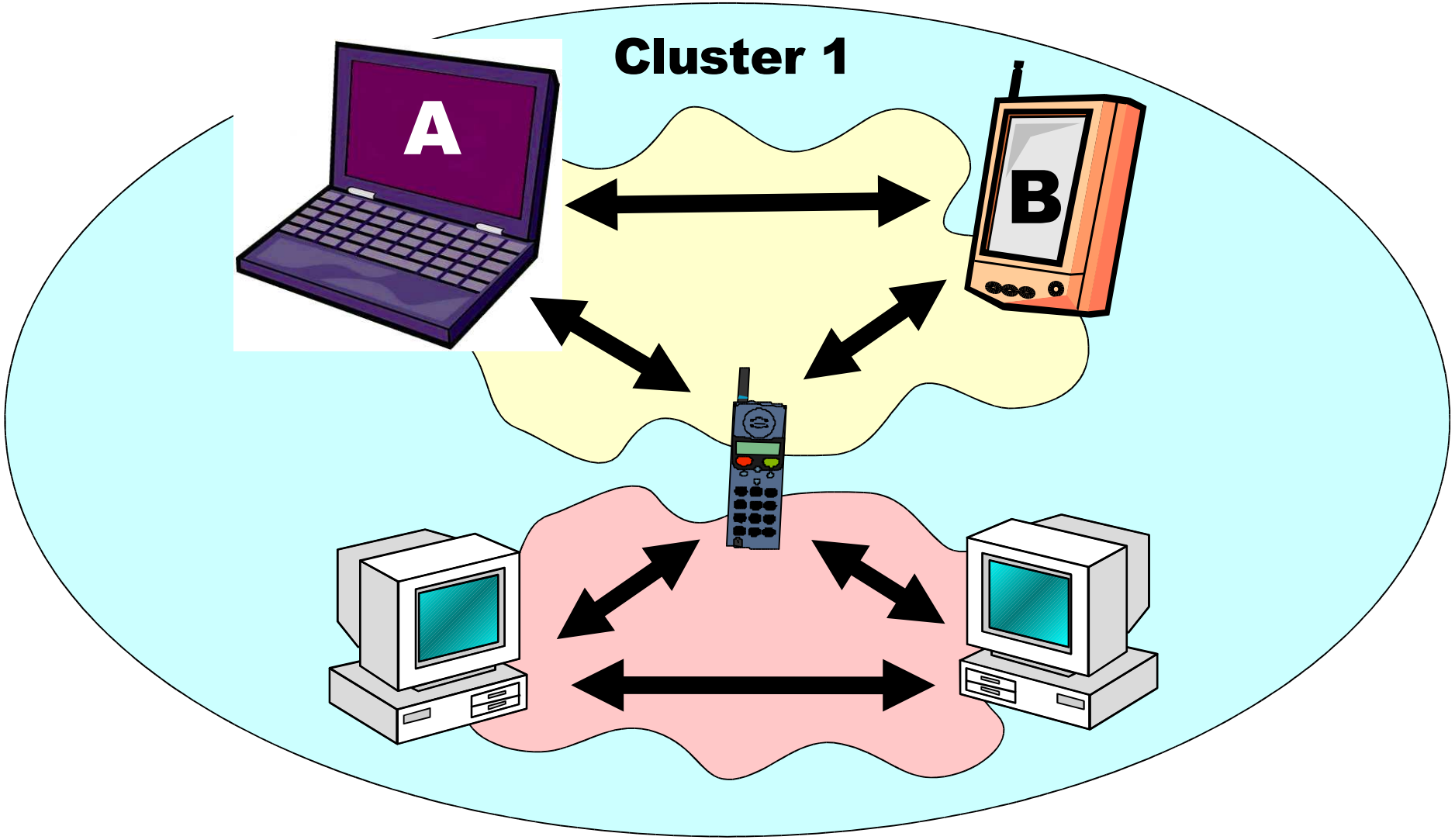
$\{Mgmt\ Data\}_{PID}$ ↔

$\{Data\}_{PID}$ ↔

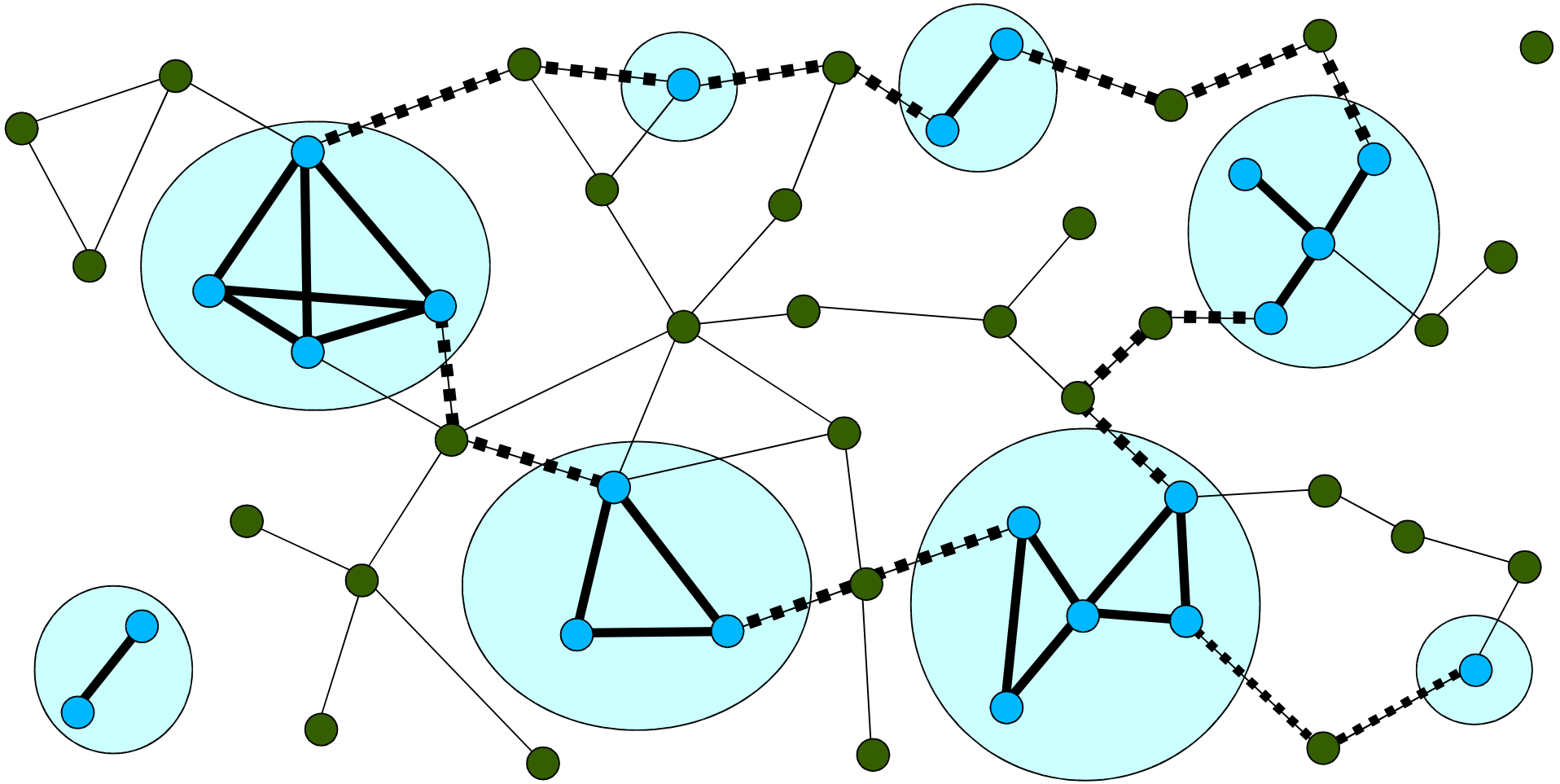
… and a Cluster is formed



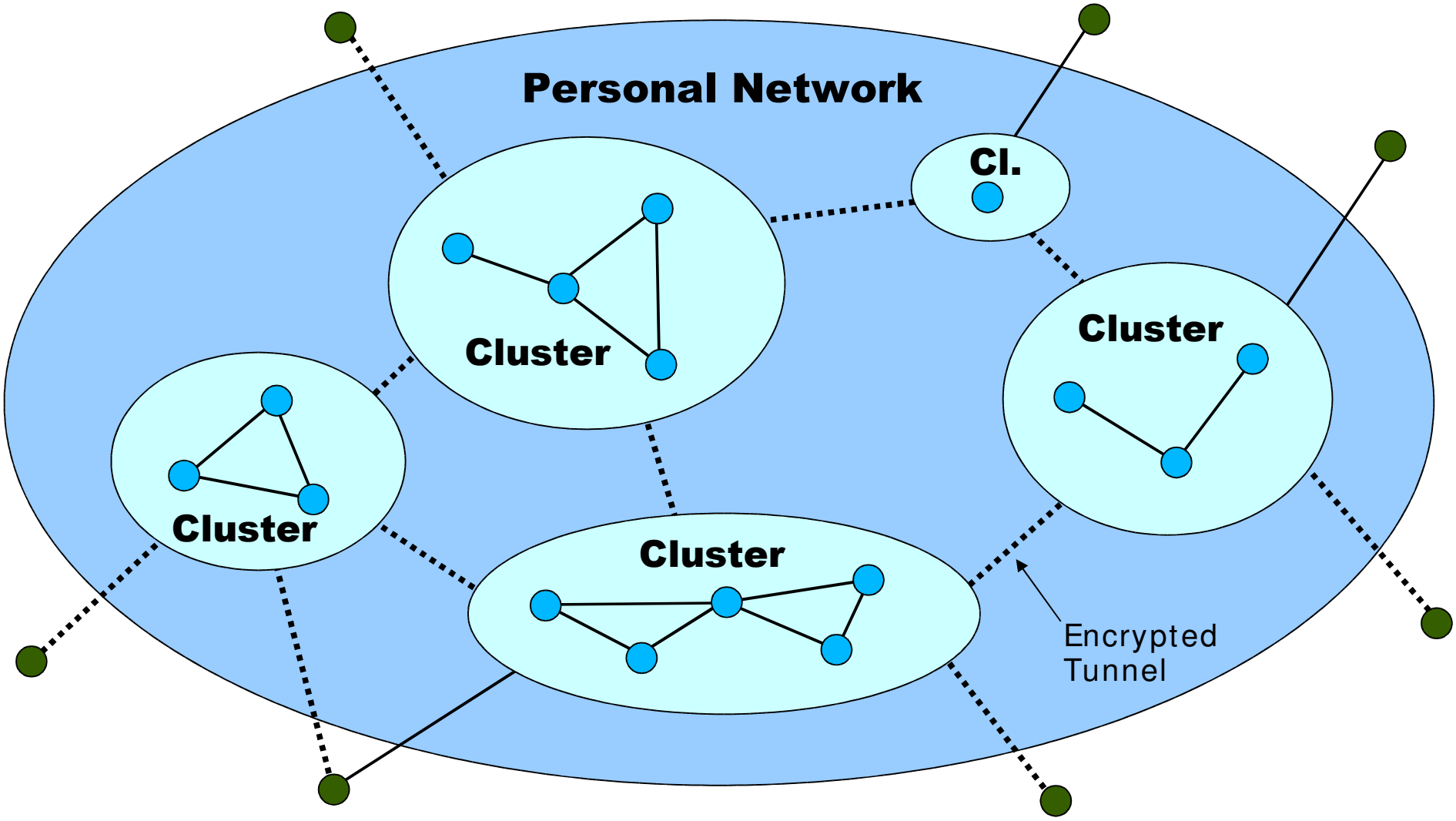
A Cluster can be multi-hop



The big picture



The architecture



Cluster conclusions

- Nodes in a Cluster share the same PID
- PID can be used to protect intra-Cluster communication, including intra-Cluster routing.
- Clusters are dynamic. Node joining and leaving as well as Cluster merging and splitting are common events.

Network functionality of a Cluster

- Secure packet forwarding
  - Offering data integrity and encryption
- Intra-Cluster routing and addressing
  - Mobile ad-hoc routing, automatic addressing
- Intra-Cluster Broadcasting/flooding capabilities
  - For service discovery, context information, routing, ...
- Edge/border/gateway node identification
  - To establish connections with Foreign Nodes and other Clusters. Edge nodes enforce security.

PN conclusions

- Consists of one or more dynamic Clusters
- Clusters are interconnected by tunnels
- Since all Nodes share the same PID, data traffic can be encrypted.
- A Node needs the correct PID to join a PN.
- However, inter-Cluster communication is dependent on Foreign Nodes and their routing mechanisms.

Network functionality of a PN

- Establishment and maintenance of encrypted tunnels between all Clusters
- Inclusion of new Nodes and exclusion of compromised Nodes
- Secure and anonymous setup and maintenance of communication with Foreign Nodes.

Security implications of the architecture

Anonymity

- Definition: A Node must never reveal its identity, including addresses, names, PIDs, etc unless the user approves it or is aware of it.
- This includes all steps:
  - A Node meets another Node
  - Communication between Personal Nodes
  - Communication between Personal Nodes and Foreign Nodes of already known Personal Networks
- Otherwise, tracking of users becomes possible by anyone!

Anonymity Solutions

- The procedure to detect Personal Nodes must never reveal identities to non-Personal Nodes.
- MAC-addresses are not kept constant.
- Network layer and up is encrypted with help of the PID.

PN security implications

- Personal Networks is person centric
- Personal Networks also have to focus on interactions with other persons:
  - Partner, children and family
  - Team work and colleagues
  - Friends and acquaintances
  - …
- And we still need security and privacy

Sharing and borrowing of Nodes

- The architecture is strongly focused around the owner concept - a person owns a Node!
- Sharing and borrowing will be a requirement:
  - Families share Nodes in the house, car, etc
  - Friends borrow each other's Nodes
  - Employees borrow company equipment for trips, etc.
  - ...
- Renting will also be a requirement:
  - Car with electronic equipments, ...

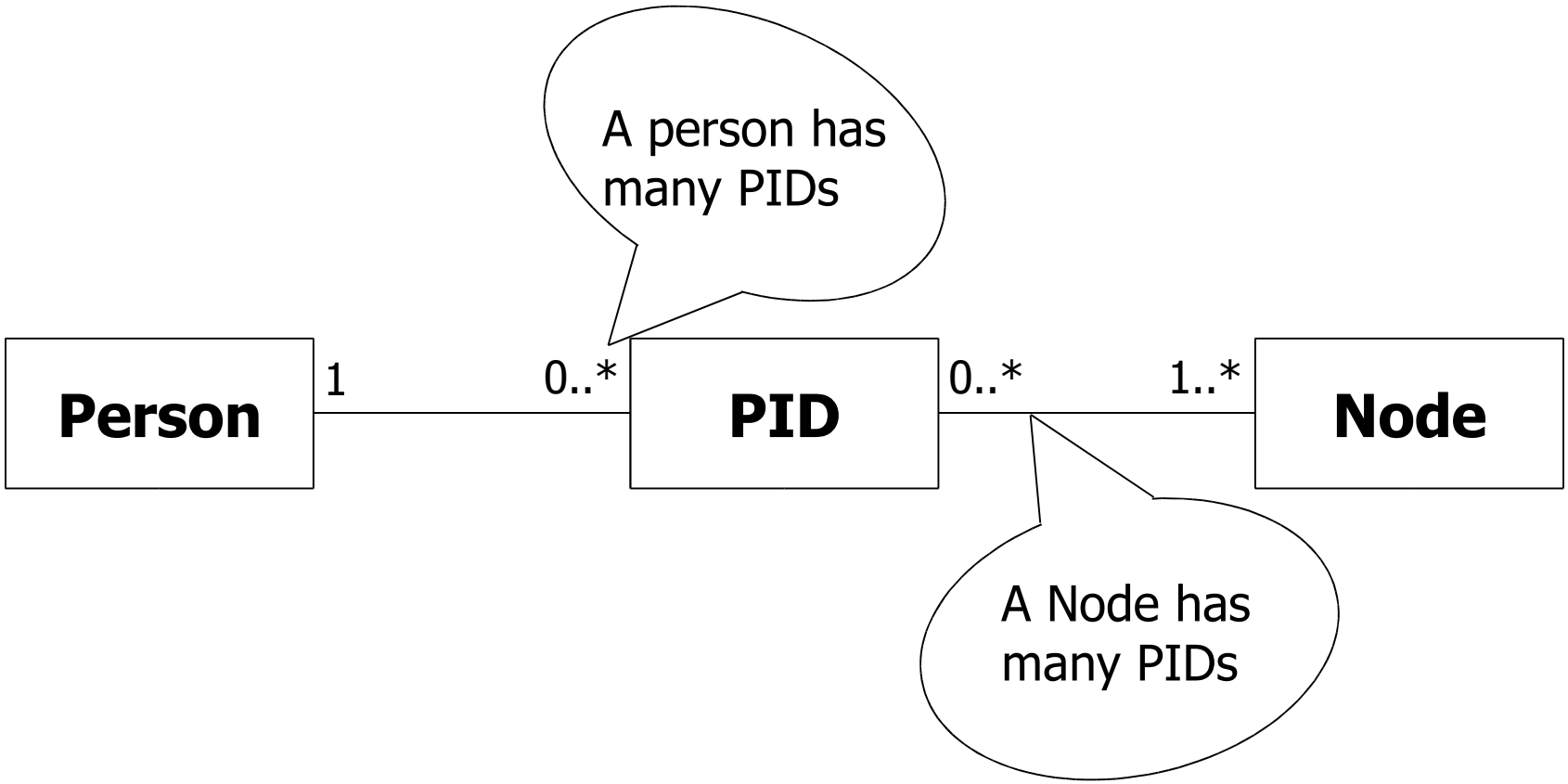
Personal vs. professional life

- A working person does not want two separate PNs, one professional PN and one private PN.
  - Only one agenda, email account, etc
  - Manage private activities from office
  - Distance working from home

The Person - PID - Node relation (1)

- A person can have two (or more) PIDs:
  - One private PID for private Nodes
  - One professional PID for the company's Nodes
  - Or more...
- A Node can be equipped with many PIDs:
  - For a family sharing a Node
  - For persons with several PIDs
  - ...

The Person - PID - Node relation (2)



Theft of devices and data

- If a Node possesses a PID, it can join that PN – What if such a Node is stolen?
- Since PIDs are different, lost Nodes can be excluded – Is this good enough?

- Data can be stolen or modified before the PID is excluded!
- There is still a need for an authentication/access rights system at the service/application layer.

PN security summary

- PID protects anonymity/privacy and routing traffic
- PID does not protect everything, because:
  - PID is insufficient for most Foreign Node communication
  - Theft of one single PN Node would compromise the whole PN
- Therefore, an application/service layer security mechanism is still needed!

A possible implementation

Requirements of a PID implementation

- Anonymous detection of Personal Nodes
- Enabling secured connections between Personal Nodes
- Personalization of not yet Personal Nodes must be easy and always possible
- Compromised Personal Nodes can be excluded
- Enabling secure communication with other Personal Networks

Extended node pairing method

- A Person pairs his Nodes (e.g. as in Bluetooth)
  - During the pairing procedure, the Nodes exchange keys, etc.
- However, n Nodes means n(n-1)/2 pairings...

- Therefore, we introduce a “transitive rule”:

If A and B are paired and B and C are paired

Then A and C are also paired

This method implements the PID model

- We know from set theory (relations):
  - Since the pairing is reflexive, symmetric and transitive, then it is an equivalence relation and divides the set of all Nodes into partitions.
- Each partition is a Personal Network
- Some things still needs to be worked out:
  - The cryptographic and practical details
  - Exclusion of compromised Nodes is not addressed
  - Sharing is not possible (Nodes with multiple PIDs)

Conclusions

Conclusions and remarks

- PID is a security policy model, that models ownership of communicating Nodes
- PID is person centric which leads to some problems when looking at interactions between persons, such as sharing and borrowing of Nodes.
- IST-MAGNET is working on an implementation (not addressing all requirements)

Further Information

- MAGNET website: http://www.ist-magnet.org/

- Martin Jacobsson, Jeroen Hoebeke, Sonia Heemstra de Groot, Anthony Lo, Ingrid Moerman, Ignas Niemegeers, "**A Network Layer Architecture for Personal Networks**", In the Proceedings of Workshop on "My Personal Adaptive Global Net: Visions and beyond", Shanghai, China, November 11-12, 2004.
- Weidong Lu, Anthony Lo, Ignas Niemegeers, "**On the Dynamics and Self-Configuration of Personal Networks**", In the Proceedings of Workshop on "My Personal Adaptive Global Net: Visions and beyond", Shanghai, China, November 11-12, 2004.
- Kaisa Nyberg, Dorgham Sisalem, "**Establishing Security in Personal Area Networks**", In the Proceedings of Workshop on "My Personal Adaptive Global Net: Visions and beyond", Shanghai, China, November 11-12, 2004.

Questions