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# Ubiquitous Computing Technology in Infrastructureless Environments

ARDOR: Service Discovery in Mobile Hospitals

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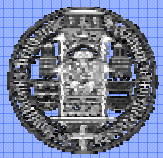
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# Agenda

- Technology Choice for Mobile Hospitals
- Service Discovery for MANETs
- ARDOR Service Discovery
- Conclusion and Future Work

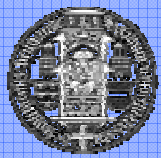
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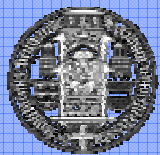
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# German Red Cross Mobile Hospitals

## Transportable hospitals

- Modularly packed camps
- Built up in areas of war or disaster
- Installed within 1-2 days
- Fully extended, size of 2 football fields
- Up to 200 inpatients and 1000 outpatients
  
- At present, deployed without any IT as
  - "not maintenancefree"
  - "not ready for use"





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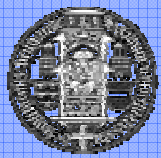
# Deficiencies of No-Tech

## Inefficiencies in workflows

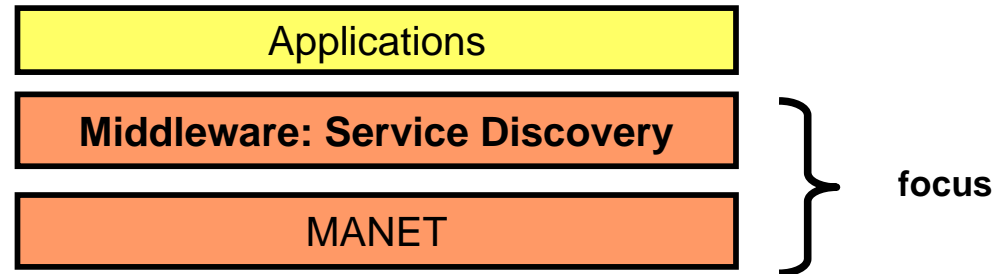
- Searching and notification of staff members and patients
- Searching for medical devices
- Lack of overview of free resources  
e.g. allocation of beds etc.

## Aim of our project ARDOR:

- Develop a maintenancefree network platform
- Provide fail-safe technology where more than 1,000 devices are interconnected
- Allow adoption of certain applications from "home" hospitals, e.g. for planning and organizing resources

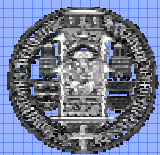


# Technology Choice for IT Solution



## Mobile Ad Hoc Network (MANET)

- Infrastructureless wireless network
  - Not based on any particular routers or access points
  - Resistant against device failures
- Configurationless at the network layer
  
- Dynamic character of resources
  - Mobility of devices
  - Power constraints of mobile devices
  - Problem: which resources are available?
    - **Middleware** to compensate this drawback for applications



# Service Discovery in MANET

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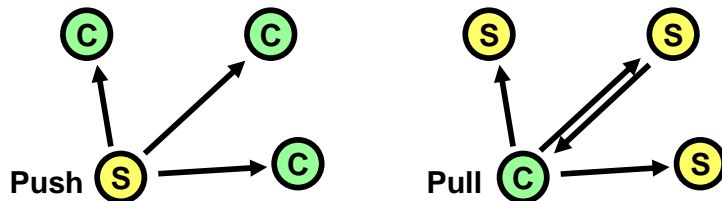
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## Function of Service Discovery

- Providing applications with up-to-date information
  - availability, location and status of medical devices and staff

## Decentralized Approach

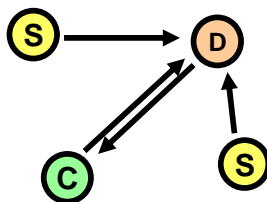
- Push model: service server periodically offers itself to all nodes
- Pull model: service seeker asks whole network for services



**Problem:** in large MANETs number of messages is too high

## Centralized Approach

- Service seeker (Client) asks service directory (D) for required service



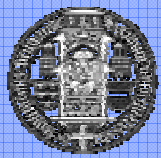
**Problem:** in large MANETs the directory becomes the bottleneck

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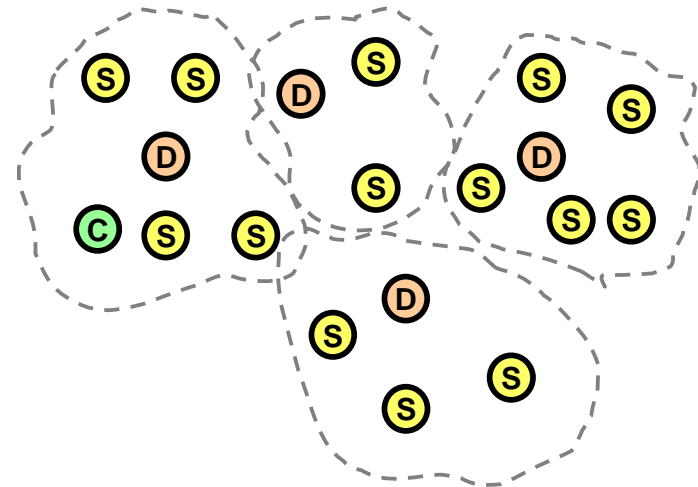
# ARDOR Service Discovery

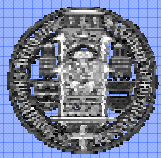
## ARDORs solution

- Scalability through hierarchical network structure
- Hybrid service discovery strategy using clusters
  - Centralized directory within each cluster
  - Decentralized search between clusters

## Two parts of ARDOR

- Clustering of nodes
- Service searching





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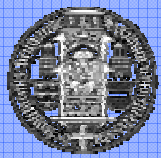
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# ARDOR - Clustering

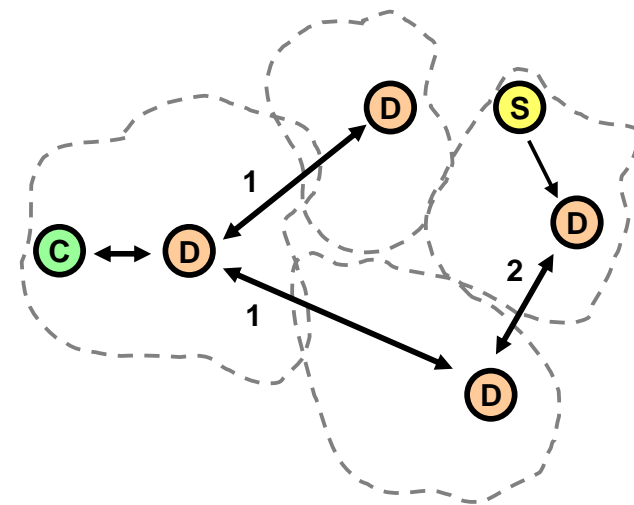
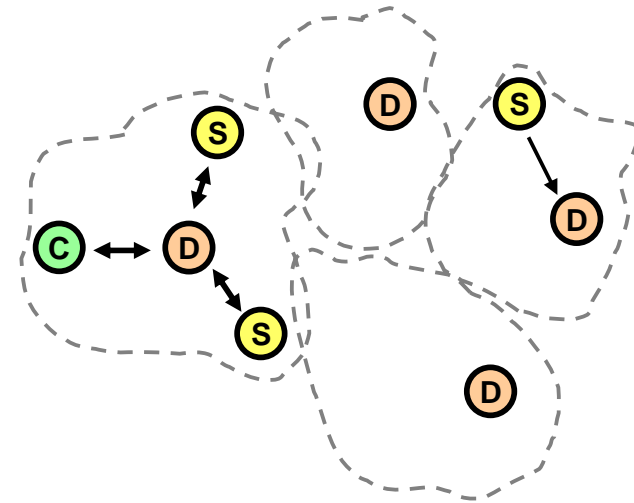
## Clustering with respect to service discovery

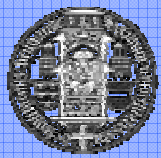
- Decentralized algorithm
- All decisions are based on local view
  - New node
    - ⇒ Node registers, if nearby directory service is found
    - ⇒ Otherwise spawns own directory service
  - Growing of clusters
    - If directory finds its registered services redundantly registered at neighboring directories
      - ⇒ Directory gives up its functionality
      - ⇒ Neighboring clusters grow
  - Shrinking of clusters
    - If discovery waiting time or traffic exceeds a given limit
      - ⇒ Cluster splits itself
- Continuously adaptation of cluster size to local dynamics of resources



# ARDOR - Search Strategy

- Services register at their local directory
- Client queries local directory for required service
- Local services are reported back
- Local directory escalates its search
  - If no instance of the sought-after service is registered for the local cluster
  - If explicitly all instances of this service type are searched for
- Reactive strategy
  - Expanding ring search
  - Caching shortens search paths





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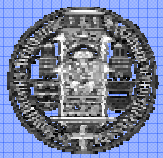
# ARDOR - First Results

	Success Rate [%]	Avg. Waiting Time [s]	Traffic [UDP hops]
Distributed Pull	95 %	0,096	3,945,949
Directory (15 fixed)	100 %	0,022	1,006,877
HYDRA (pre-version)	100 %	0,017	584,792

Simulator: JiST/SWANS

Parameters: - 300 nodes total

- 50 servers, each server implements 2 of 5 service types
- 6 clients requesting every second one service type
- 300s simulation time
- AODV routing protocol
- Field 2000m x 1000m, random placement, random walk



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# Conclusion

- Ubiquitous computing technology enhances work flows in mobile hospitals
- MANETs provide a maintenancefree and robust network solution
- ARDOR service discovery provides applications with up-to-date view
  - Clustering allows scaling for large and dynamic networks
  - Significant reduce of traffic

## Future Work

- Further analysis of robustness of ARDOR
- Automatic performance-tuning in new environments