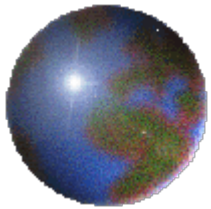
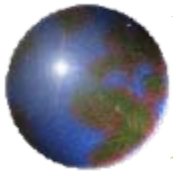


Mobile Ad hoc Networks

Frank Kargl

Chaos Computer Club Ulm

Vorher eine wichtige Meldung



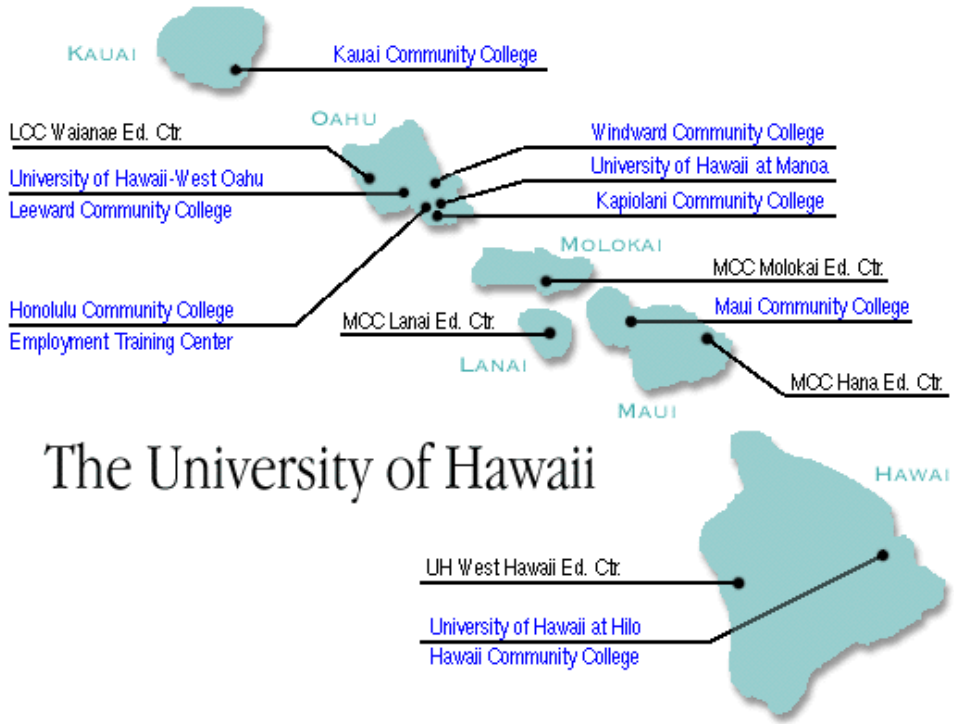
Übersicht

- Wireless LANs
- Mobile IP
- Mobile Ad hoc Networks (MANET)
- IETF MANET WG
- Protokolle
- Zukünftige Anwendungen

Historie der Wireless LANs

1970: Norman Abramson,
Univ. of Hawaii:
ALOHA Network

Vorläufer von
CSMA

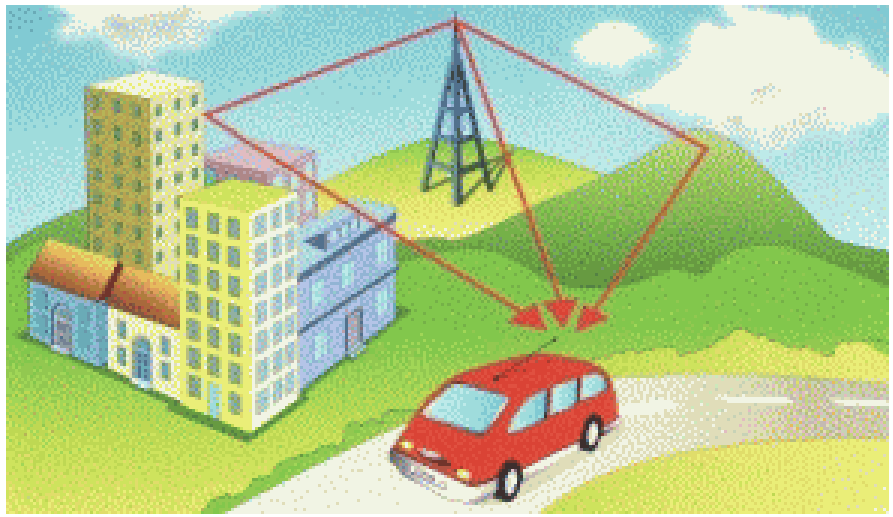


Drahtlose Übertragungstechniken

- Funk (10^4 – 10^9 Hz)
- Mikrowellen (10^9 – 10^{11} Hz)
- Infrarot (10^{11}-10^{14} Hz)
- Sichtbares Licht / Laser (10^{14}-10^{15} Hz)

Wireless LANs

- Im folgenden: Funk Technologien
- Probleme bei Funk:
  Abschattung, Laufzeitunterschiede, ...

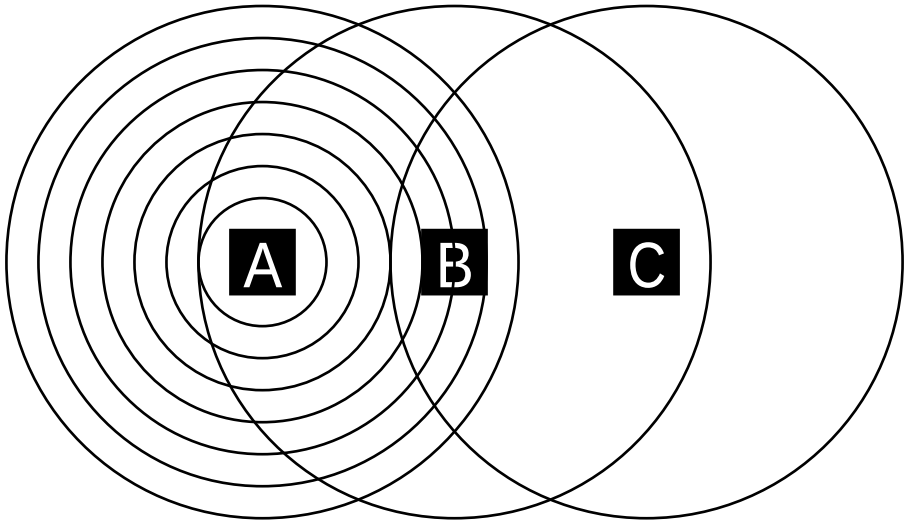


Ethernet via Funk?

CSMA/CD

Carrier Sense

- Hidden Stations

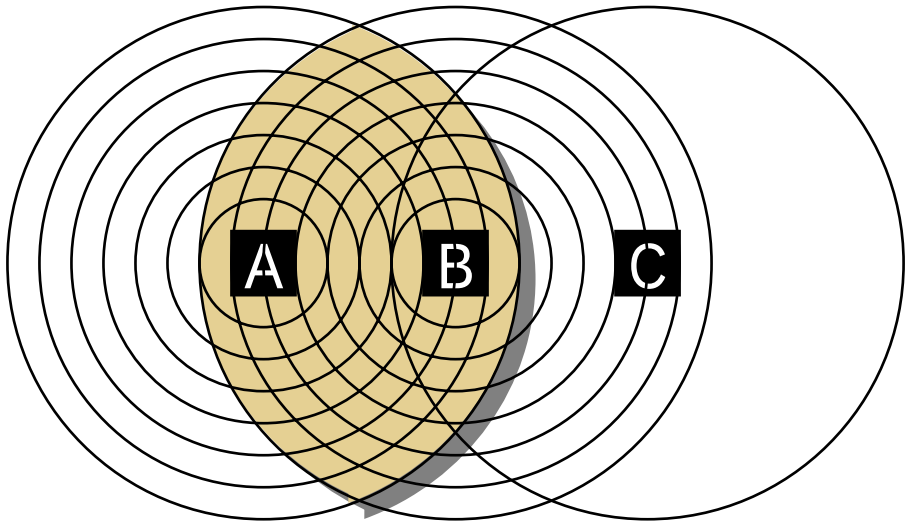


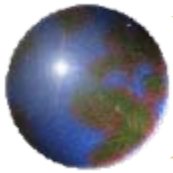
Ethernet via Funk?

CSMA/CD

Collision Detection

- Full-duplex notwendig
- Erkennung beim Sender sagt nichts über Empfänger





Weitere Probleme

- Partitionierung der Netzwerke
- Mobility und Roaming
- Security
- Power Saving

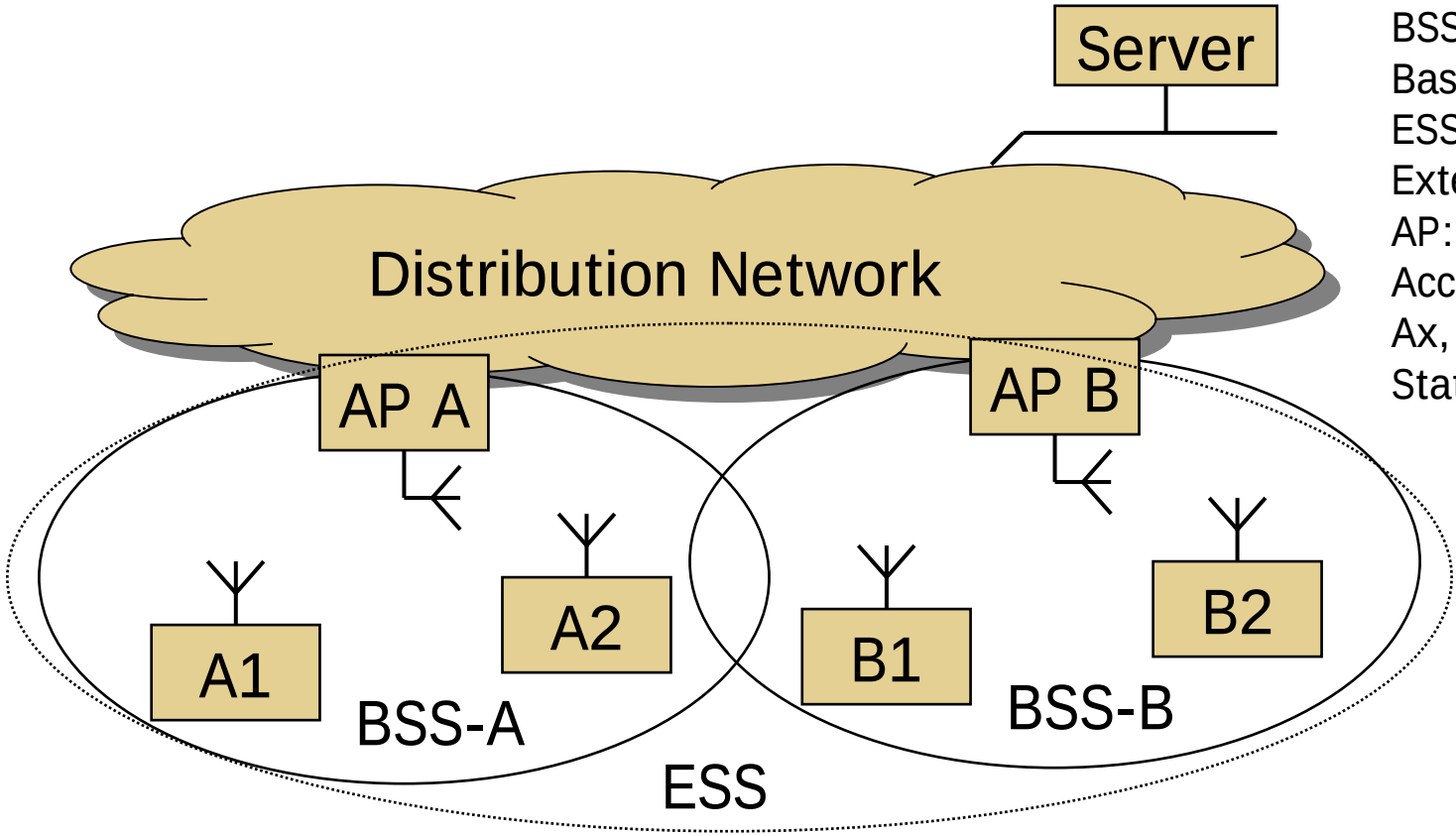
IEEE Protokolle

<table>
<tr><td colspan="4">Transport Layer (4)</td></tr>
<tr><td colspan="4">Network Layer (3)</td></tr>
<tr><td rowspan="2">Data Link Layer (2)</td><td colspan="3">Logical Link Control (LLC)</td></tr>
<tr><td colspan="3">Medium Access Control (MAC)</td></tr>
<tr><td rowspan="2">Physical Layer (1)</td><td colspan="3">Physical Layer Convergence Protocol (PLCP)</td></tr>
<tr><td>DSSS</td><td>FHSS</td><td>Infrarot</td></tr>
</table>

IEEE Protokolle

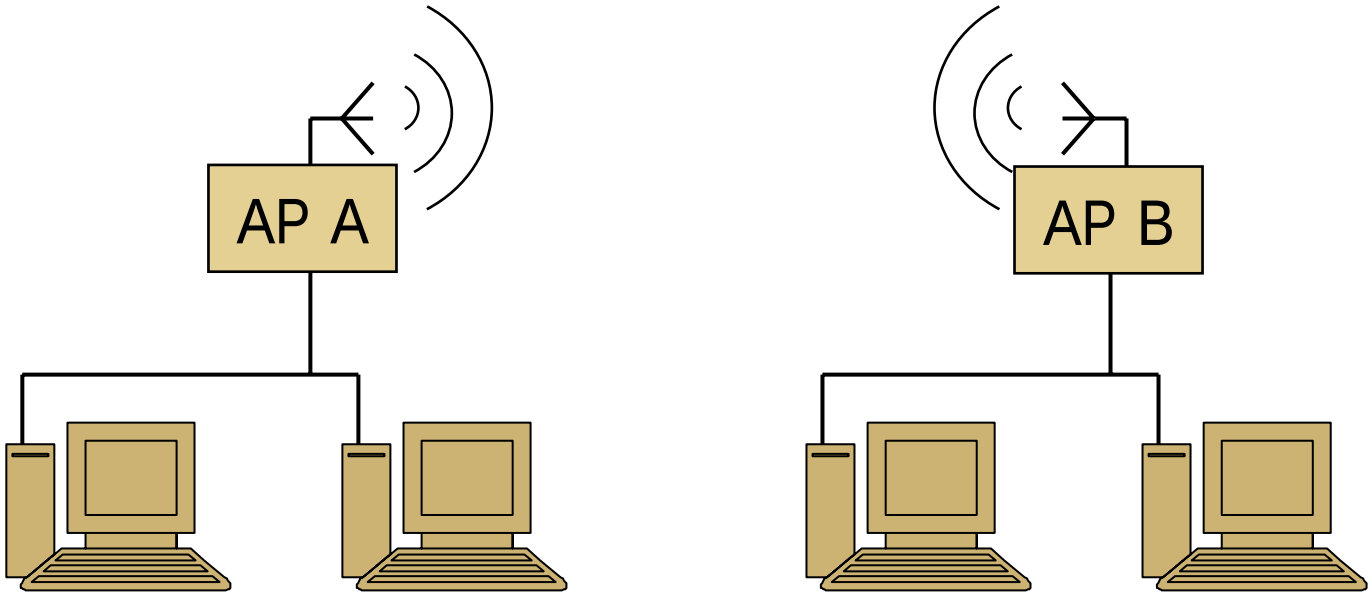
- IEEE 802.11 Wireless LANs
  - 802.11a Highspeed 5 GHz (50 Mbps)
  - 802.11b Highspeed 2.4 GHz (11 Mbps)
  - 802.11e QoS
  - 802.11x Authentication etc.
- IEEE 802.15
  Wireless Personal Area Networks (WPAN)
- IEEE 802.16
  Fixed Broadband Wireless Access Systems

Netzwerkaufbau mit IEEE 802.11

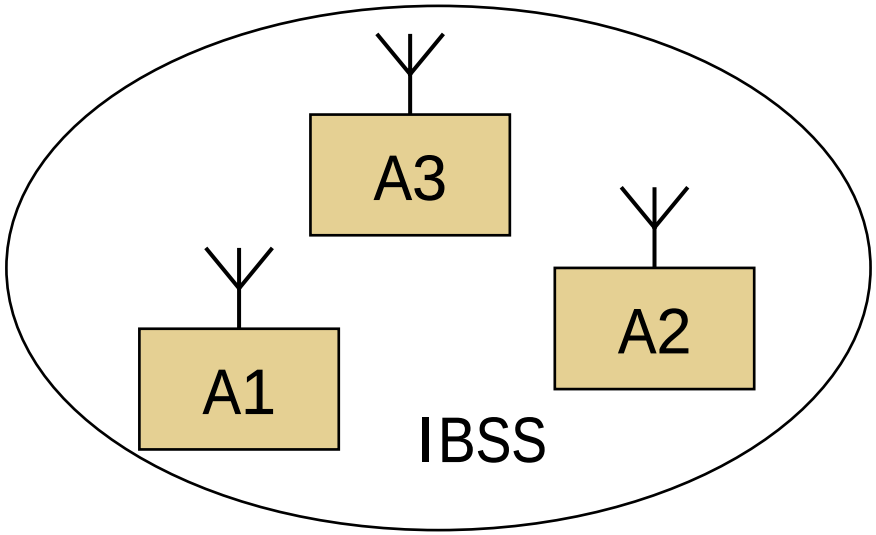


BSS:
Basic Service Set
ESS:
Extended Service Set
AP:
Access Point
Ax, Bx:
Stations

Point-To-Point



Ad hoc mode



IBSS:
Independent Basic Service Set

Eingesetzte Funktechnologien

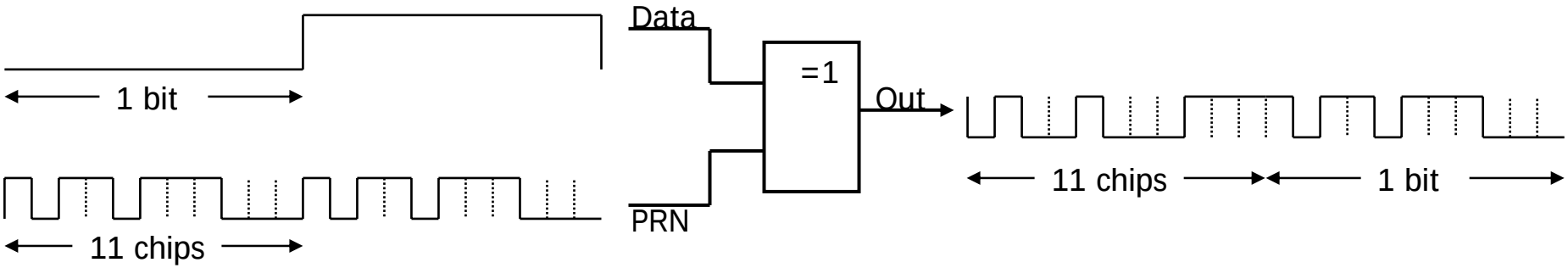
PHY Layer:

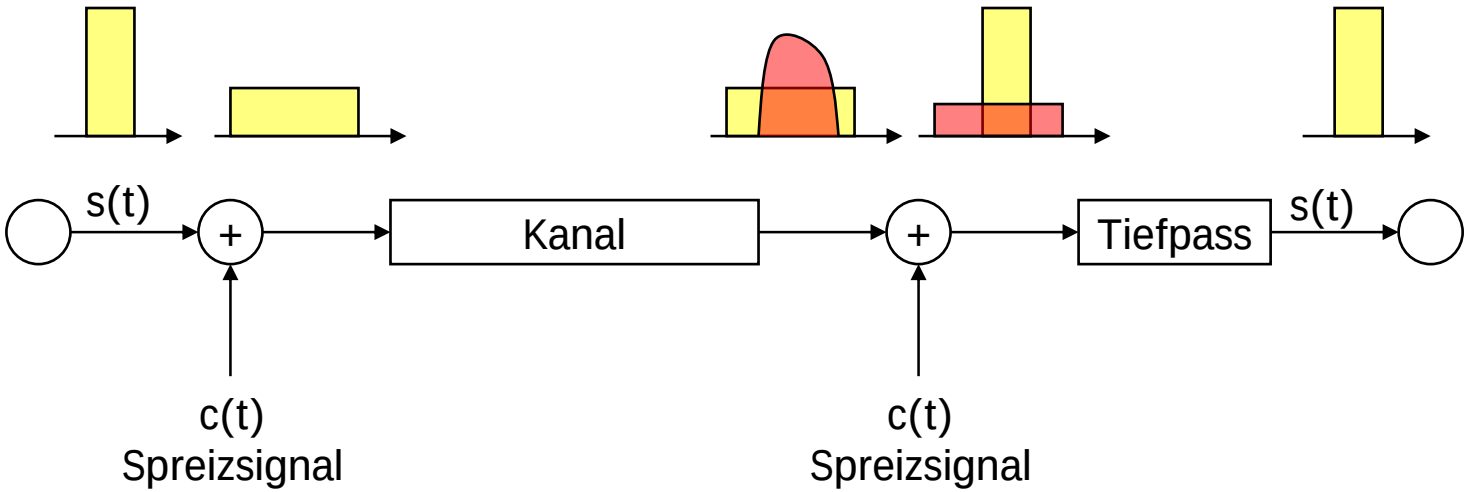
2 * RF, 1 * Diffus IR

RF:

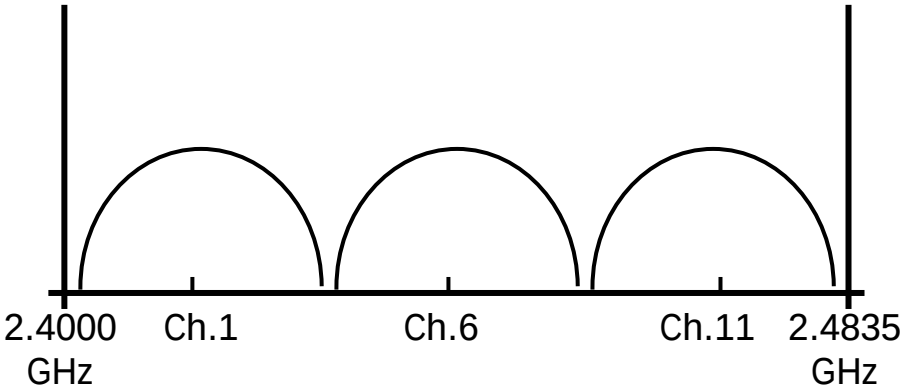
- 2.4 GHz ISM Band
- Direct Sequence Spread Spectrum
  DSSS, 1/2/11 Mbps
- Frequency Hopped Spread Spectrum
  FHSS, 1/2 Mbps

Direct Sequence Spread Spectrum





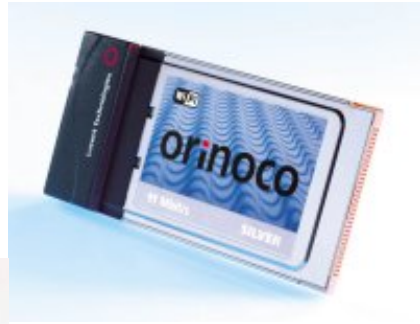
Kanalbelegung

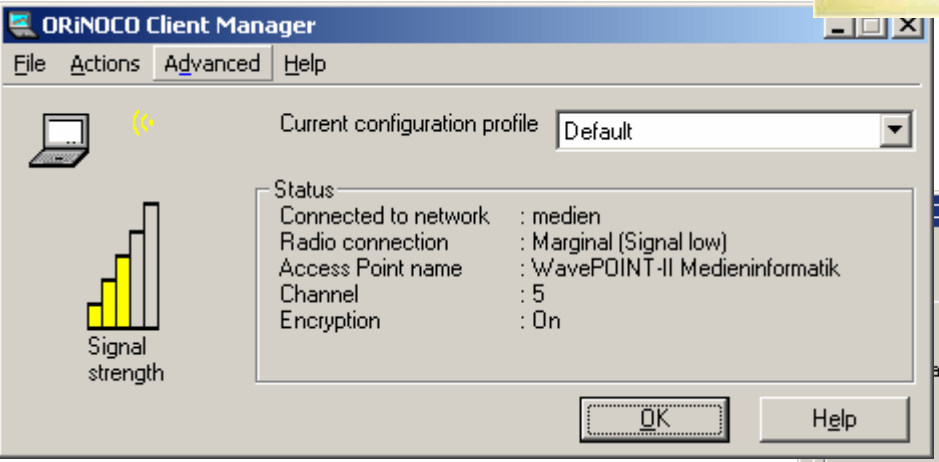


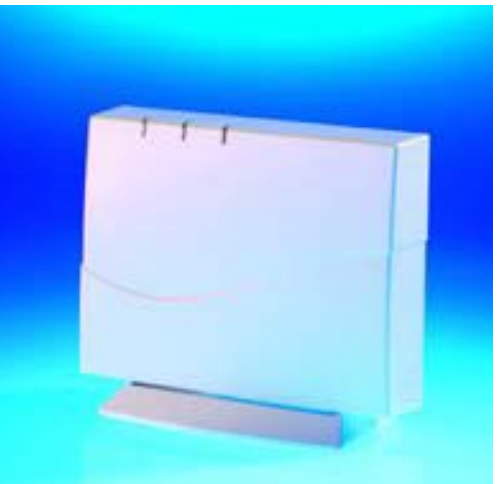
Weitere Punkte

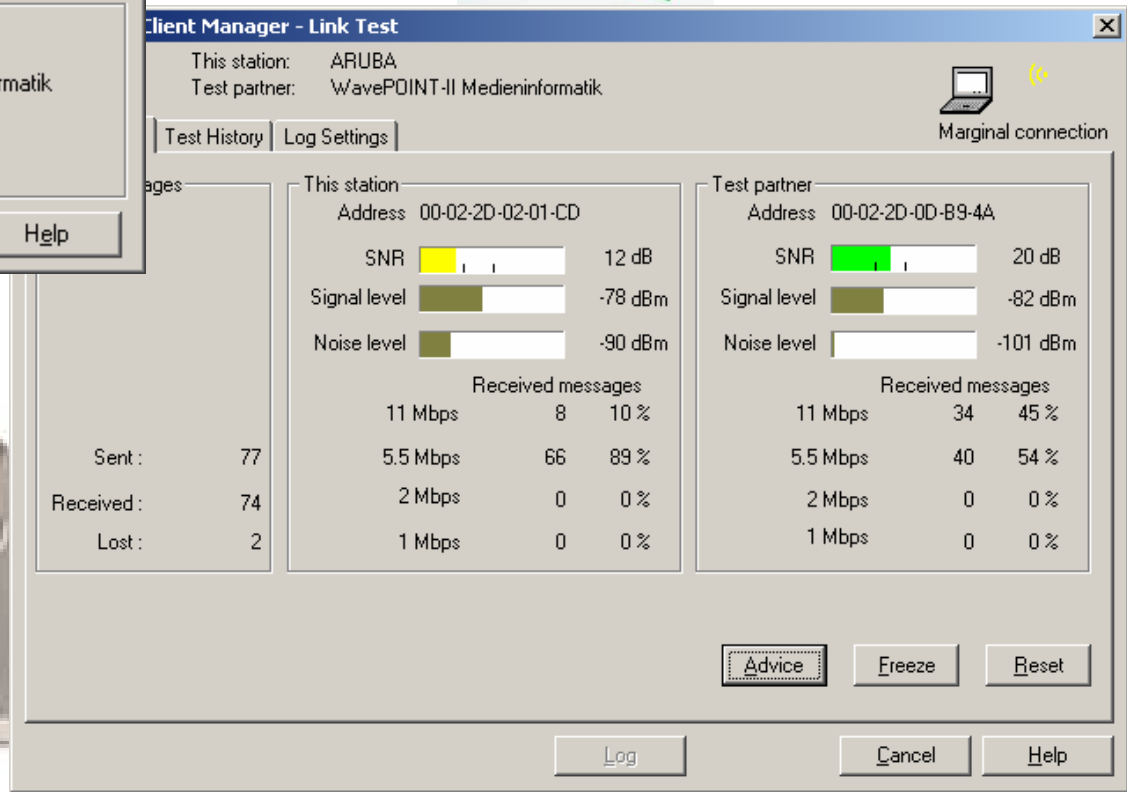
- Kompatibilität: WiFi (www.wirelessethernet.org)
- Security (WLEC, 128 bit)
- Viele Hersteller (Lucent, Cisco ...)
- Bluetooth: 802.11 light

Lucent/Orinoco





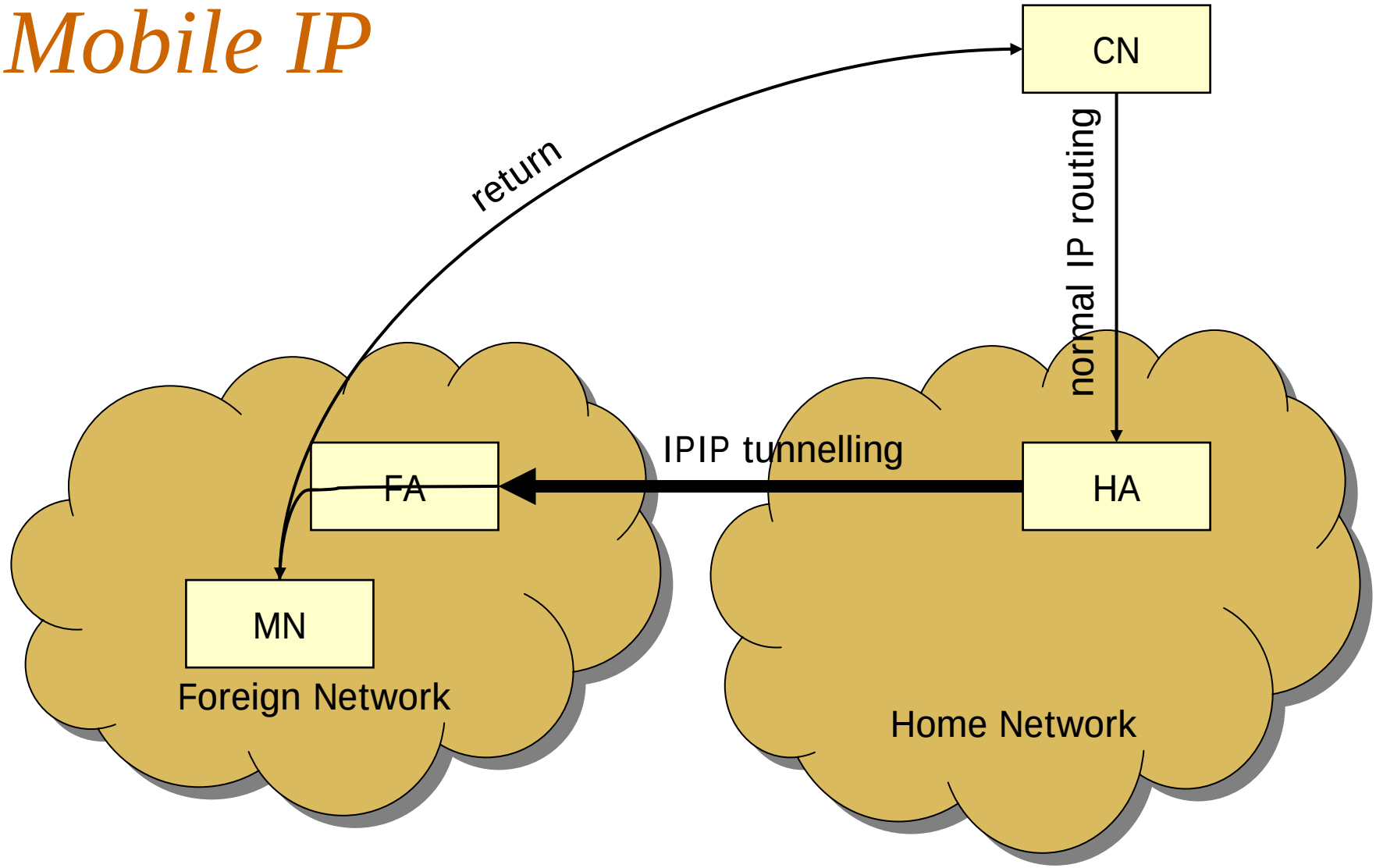




Mobile IP

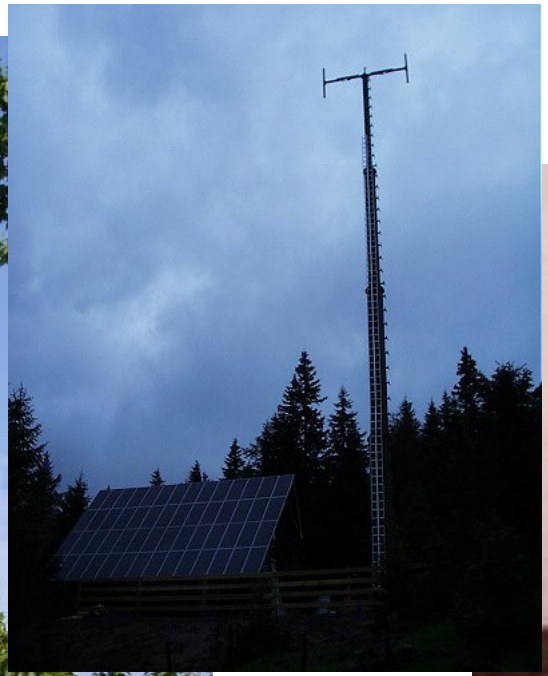
- Roaming zwischen APs nur bei gleichem IP Subnetz
- Lösungen:
  - DHCP
  - VLANs
  - Mobile IP

Mobile IP


CN
return
normal IP routing
IPIP tunnelling
FA
HA
MN
Foreign Network
Home Network

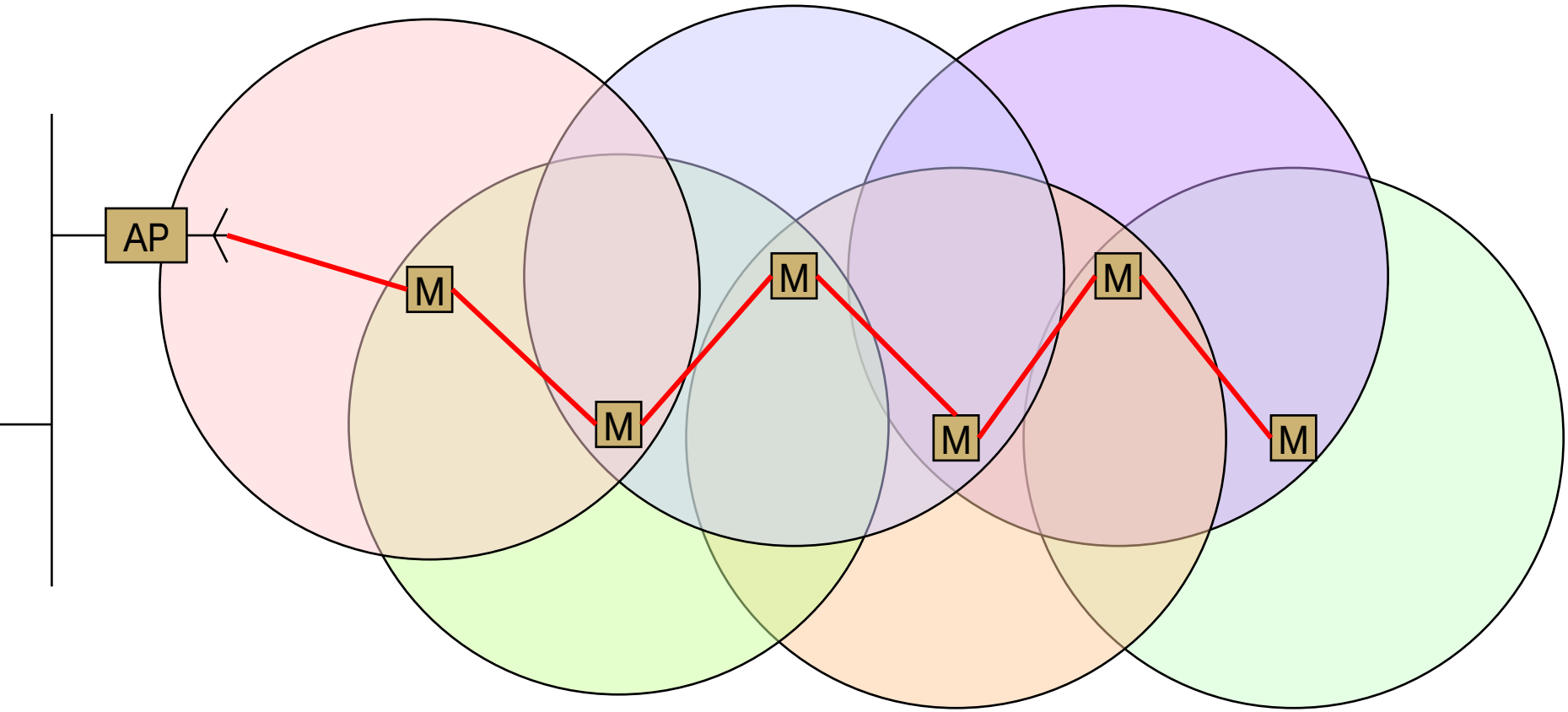
Bestehendes Problem

Nähe zur Basisstation ???



Idee: Mobile Ad hoc Networking

Jede Station ist gleichzeitig auch Router



IETF Working Group

- Militärische Anwendungen > 30 Jahre
- Seit 97 IETF WG
  - RFC 2501:
    Routing Protocol Issues and Evaluation Considerations
  - 10 Drafts
  - 2 davon kurz vor Experimental RFC

Wieso neue Routingprotokolle?

- RIP: konvergiert zu langsam
- OSPF: jede Änderung wird geflutet
- Frühe (militärische) Ansätze:
  - Flood and Trace
  - Hot-Potato-Routing

Charakteristische Eigenschaften

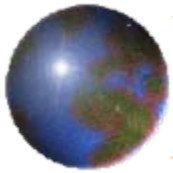
- Häufige Topologiewechsel
  - Zufällig
  - Uni-/Bidirectional
- Geringe Bandbreite
- Geringe Leistung (Batterie)
- Eingeschränkte physik. Sicherheit

IP vs. Layer 2

- Realisierung in IP
  - Verbindung versch. Wireless LAN Technologien in einem Gerät
  - Routing bleibt in der Netzwerkschicht
- Realisierung auf Layer 2
  - Für den Benutzer transparent(er)

Eigenschaften (RFC 2501)

- Distributed Operation
- Loop-freedom
- Demand-based Operation
- Proactive Operation
- Security
- ´Sleep´ Period Operation
- Unidirectional Link Support



Einteilung

- Table-driven vs. On-Demand
- Multicast vs. Unicast

MANET Routing Protokolle (1)

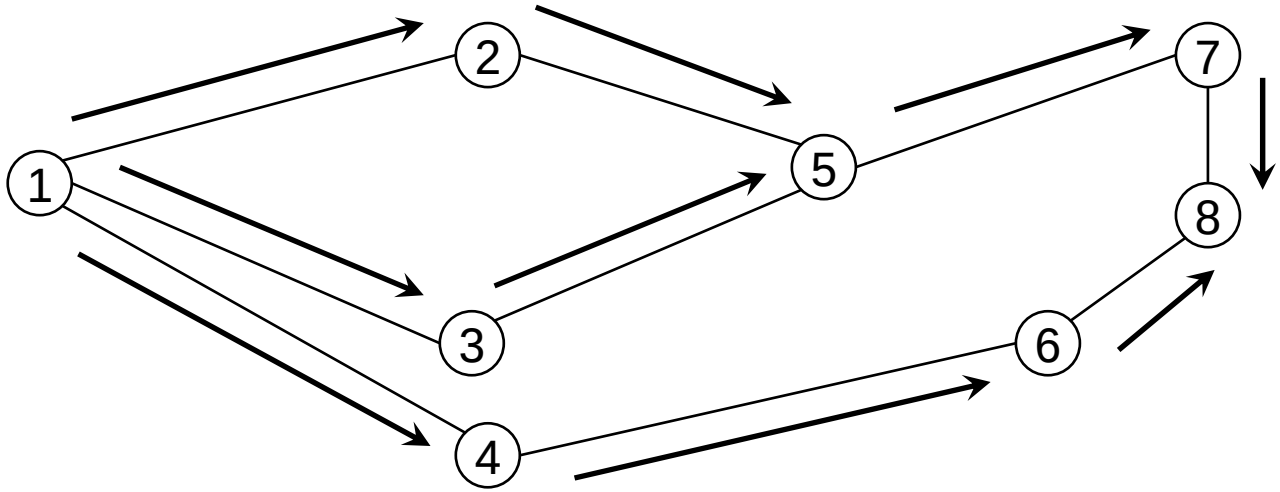
- Ad hoc On-Demand Distance Vector Routing (AODV)
- Dynamic Source Routing (DSR)
- Fisheye State Routing (FSR)
- Landmark Routing (LANMAR)
- Optimized Link State Routing (OLSR)
- Temporally-Ordered Routing Algorithm (TORA)
- Topology Broadcast based on Reverse Path Forwarding (TBRPF)

MANET Routing Protokolle (2)

- Differential Destination Multicast (DDM)
- Multicast AODV
- On-Demand Multicast Routing Protocol (ODMRP)
- Simple Protocol for Multicast and Broadcast in MANETs

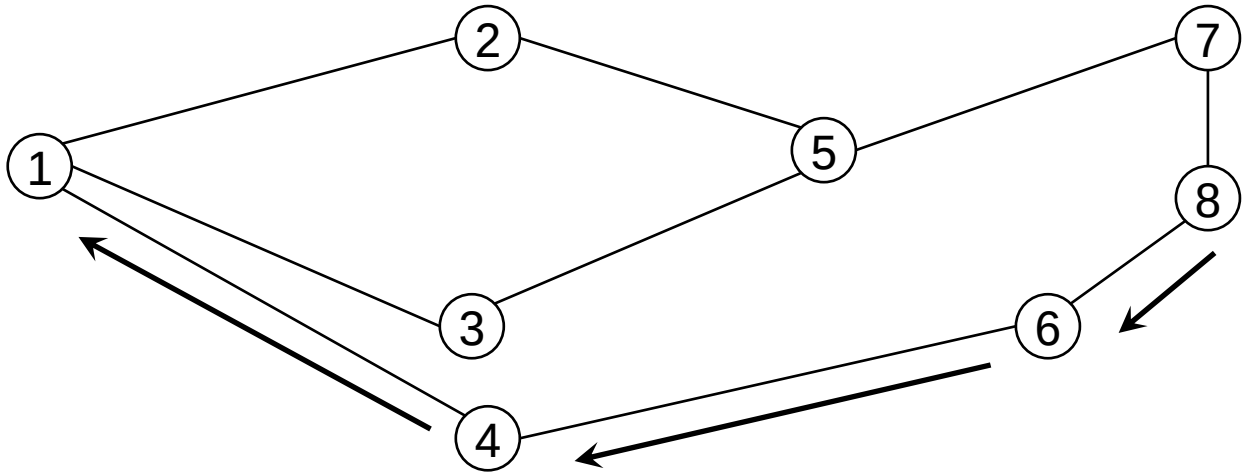
- Internet MANET Encapsulation Protocol (IMEP)

AODV (RREQ)



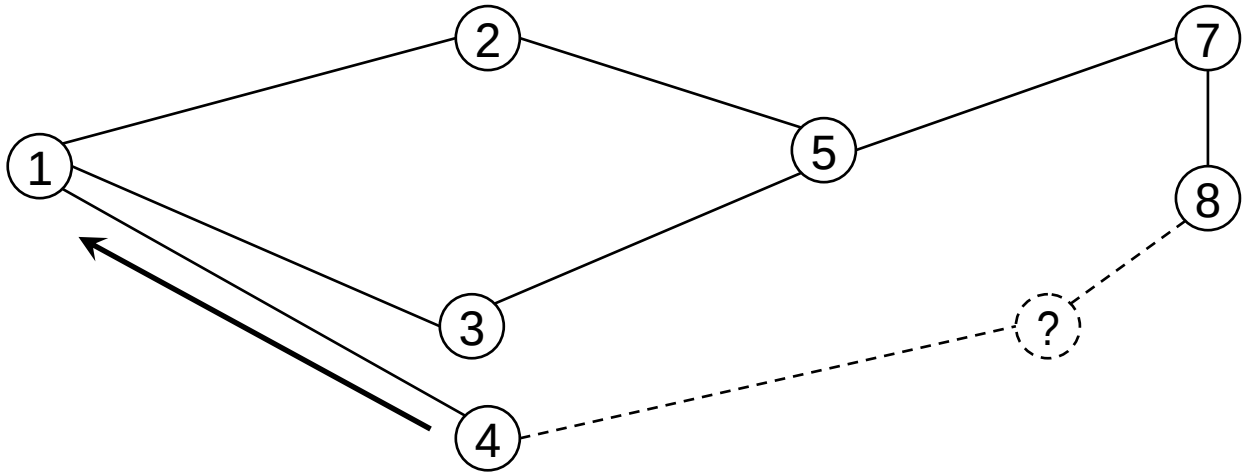
- Basiert auf Distance Vector
- Route Requests
- Flooding
- Sequence Numbers
- Stationen merken sich für jeden Req. eingehendes Interf.

AODV (RREP)



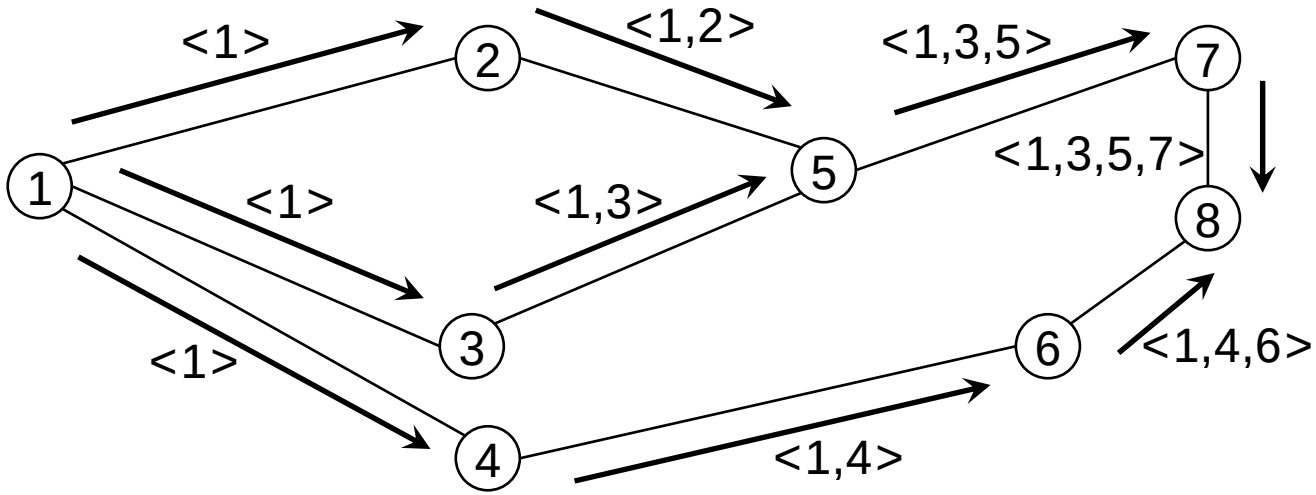
- Antworten werden zurückgeschickt, sobald einer der Zwischenknoten die Route kennt
- ... oder falls der Request beim Zielhost ankommt
- Beim Rückweg lernen die Zwischenknoten die Route

AODV (RERR)



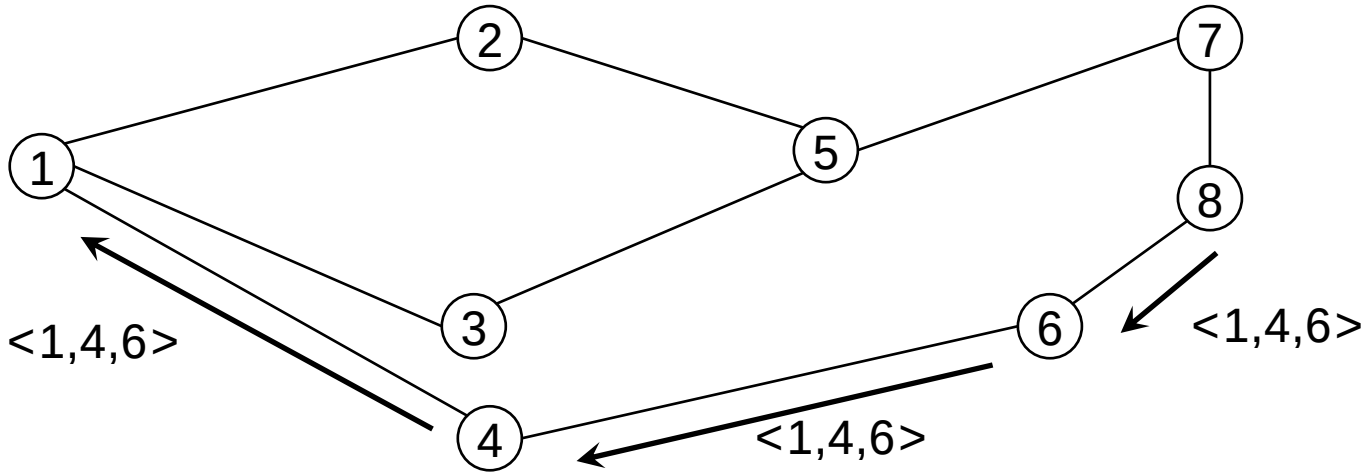
- Wird eine Route unbrauchbar, schicken die Stationen Route Error Meldungen
- Erneute Route Discovery
- Route Timeout

DSR (Route Discovery)



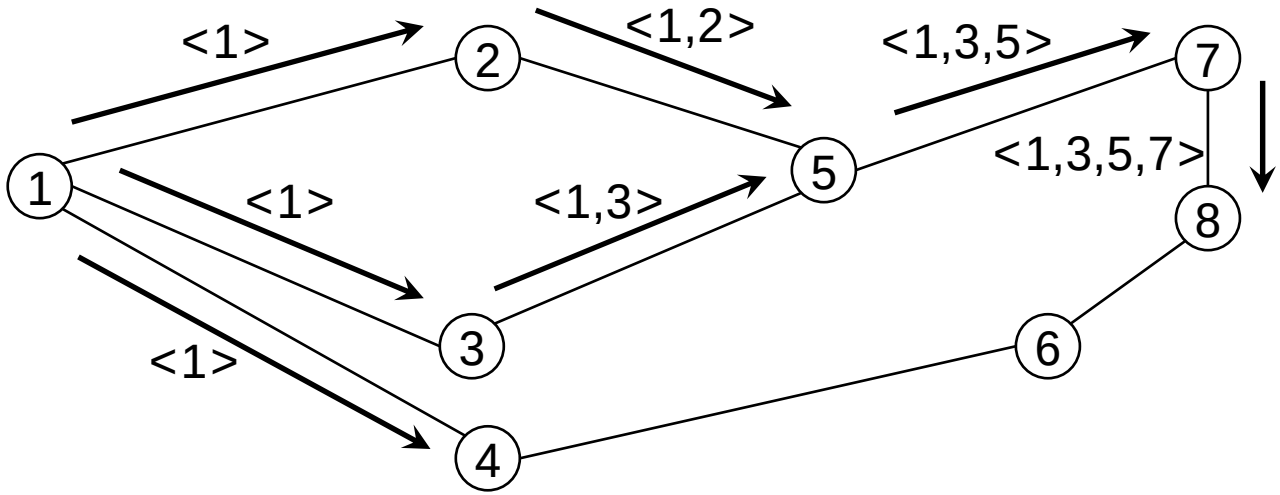
- Route Requests
- Flooding
- Sequence Number
- Request enthält Wegliste

DSR (Route Discovery)



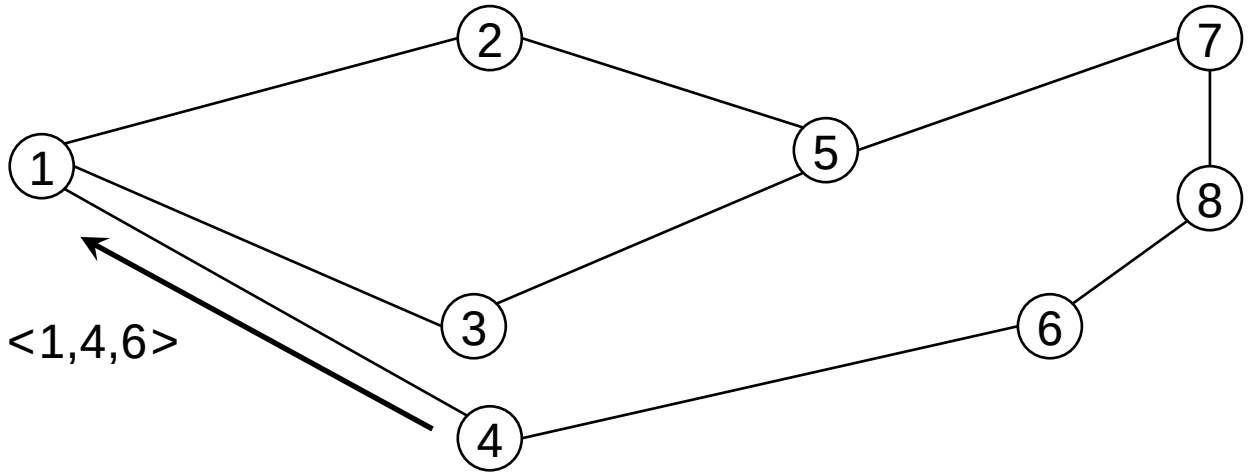
- Antworten enthalten Wegliste
- Entweder via Reverse Route
- Oder erneute Route Discovery mit angefügter Wegliste
- Pakettransport via Source-Routing

DSR (Route Discovery)

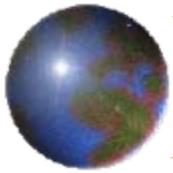


- Wenn Route schon bekannt, direkte Antwort

DSR (Route Discovery)



- Route Maintenance
  ähnlich AODV



Andere Protokolle

- Hierarchischer Netzaufbau (Cluster)
- Ungenauere Informationen bei größerer Entfernung
- Einbeziehung physikalischer Information (z.B. Signalstärke)

Agent-based Routing

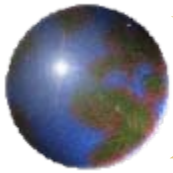
- Schoonderwoerd: Ant-based Routing
- MIT Media-Lab, Minar:
  Mobile Software Agents for Dynamic Routing

Stand der Forschung

- Bisher hauptsächlich Tests der Protokolle im NS2 Simulator
- Einige frühe Reallife Implementierungen auf Linux oder BSD Basis
- Offene Punkte:
  - Security
  - TCP
  - ...

Anwendungen

- Erweiterung bestehender Funknetze
  - Chaos Communication Congress
  - Wiese vor der Uni
- Mobiltelefone ohne Basisstationen
  - … und Kosten?



Anwendungen

- Kommunikation zwischen Verkehrsteilnehmern
  - Massive Einsparungen beim Aufbau der Infrastruktur
- Spontane Vernetzung von Städten
  - Irgendjemand hat seinen Rechner immer an

Vernetzungsprojekte

- Wavewan (Martin Steldinger) – http://www.wavewan.de/
- Kommerz: DIRC – http://www.dirc.net/
- Ulm ???