Opportunistic Ad Hoc Networking: the Case for Car to Car Communications

Mobiquitous 2005

Mario Gerla
Computer Science Dept
UCLA

What is an opportunistic ad hoc net?

- A wireless ad hoc extension of the wired/wireless infrastructure
- It coexists and often bypasses the infrastructure
- It is generally low cost and small scale

Opportunistic Ad Hoc Networking examples

- Indoor W-LAN extended coverage
- Hot spot (Mesh Networks) extensions
- Group of friends sharing an expensive resource (eg, 3G)
- Peer to peer networking in the urban vehicle grid

Traditional ad hoc net

- Civilian emergency, defense applications
- Typically, large scale
- Instant deployment
- Infrastructure absent (so, must recreate it)
- Very specialized mission/function (eg, UAV scouting behind enemy lines)
- Critical: survivability, QoS, jam protection
  Not critical:Cost, Standards, Privacy

Opportunistic ad hoc net

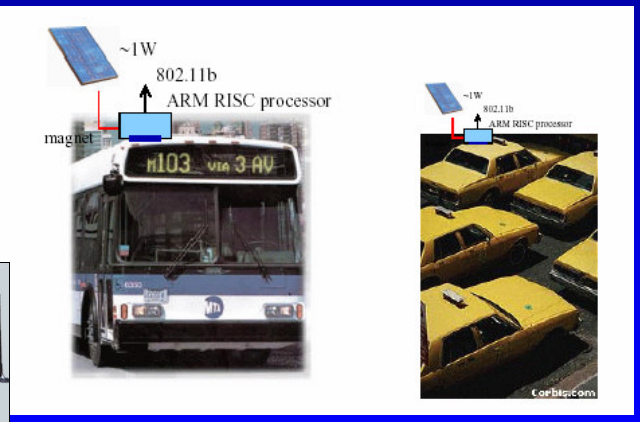
- Commercial, “commodity” applications
- Mostly, small scale
- Cost is a major issue (eg, ad hoc vs W-LAN vs 2.5 G)
- Connection to Internet often available
- Need not recreate “infrastructure”, rather “bypass it” whenever it is convenient
- “Proximity” applications
- Standards are critical to cut costs and to assure interoperability
- Privacy, security is critical

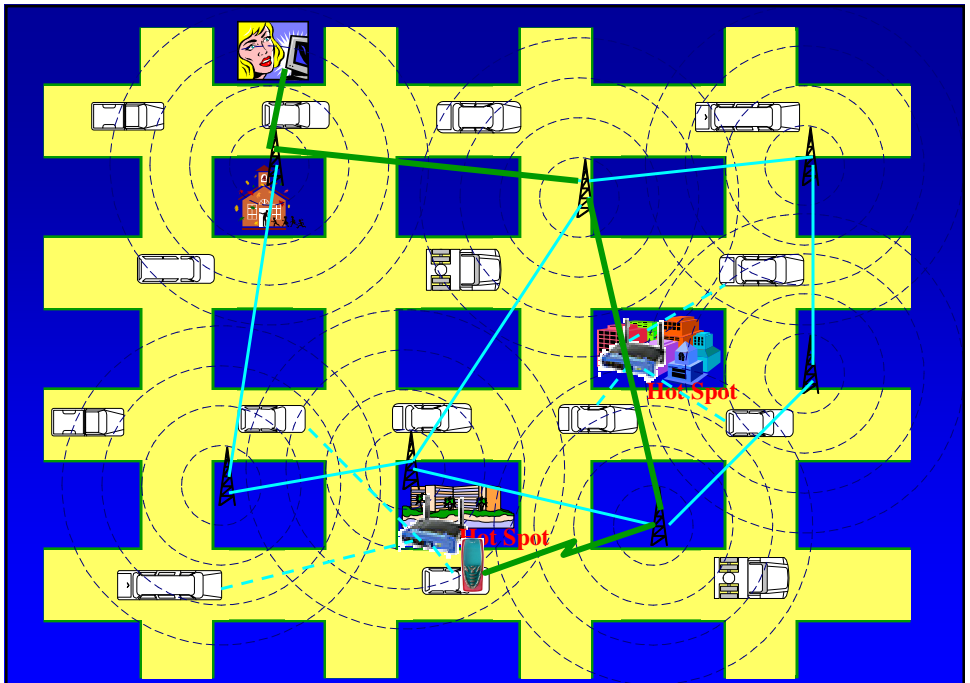
Why opportunistic ad hoc networking?

- **All Internet access will soon be wireless**
- **Most Internet terminals will be mobile with multiple radio interfaces (WiFi, Bluetooth, 3G etc)**
- **Yet, “single hop” access from terminal may not be feasible, or may not be efficient!**
  - **Obstacles; distance**
  - **Cost**
  - **Inefficient use of resources**
  - **Proximity networking application**
  - **etc**
- **Enter Opportunistic multi-hop networking**

Opportunistic piggy rides in the urban mesh

Pedestrian transmits a large file in blocks to passing cars, busses
The carriers deliver the blocks to the hot spot



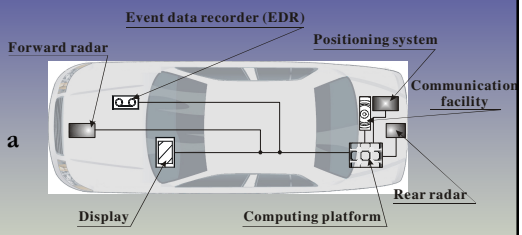


Vehicular Grid as Opportunistic Ad Hoc Net

DSRC* : Enabler of Novel Applications

- Car-Car communications at 5.9Ghz
- Derived from 802.11a
- three types of channels: Vehicle-Vehicle *service*, a Vehicle-Gateway *service* and a *control broadcast* channel .
- Ad hoc mode; and infrastructure mode
- 802.11p: IEEE Task Group that intends to standardize DSRC for Car-Car communications

* DSRC: Dedicated Short Range Communications



DSRC Channel Characteristics

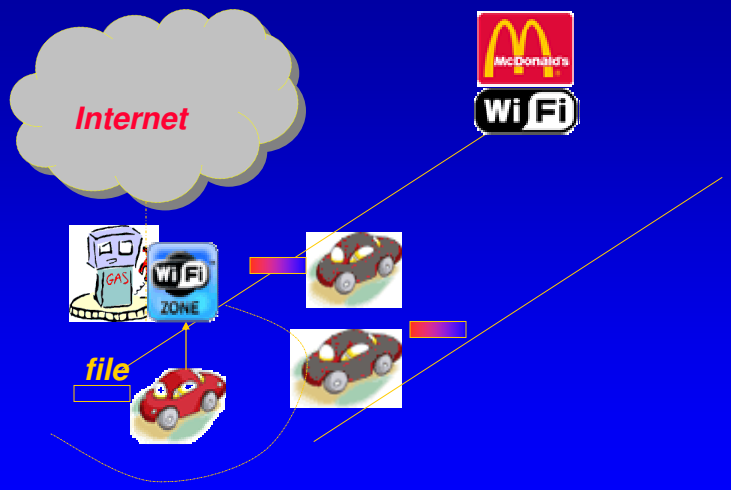
Parameter	Value
Range	1000m
Frequency Band	5.9Ghz
Speed	$\leq$ 85mph
Data Rates	6-27Mbps(depending on Range)

CarTorrent : Opportunistic Ad Hoc networking to download large multimedia files

Alok Nandan, Shanky Das
Giovanni Pau, Mario Gerla
WONS 2005

You are driving to Vegas
You hear of this new show on the radio
Video preview on the web (10MB)

Highway Infostation download



Incentive for "ad hoc networking"

Problems:

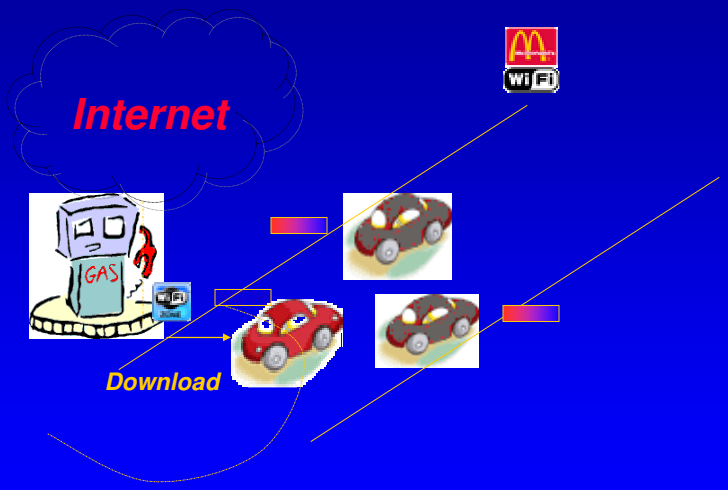
Stopping at gas station to download is a nuisance

Downloading from GPRS/3G too slow and quite expensive

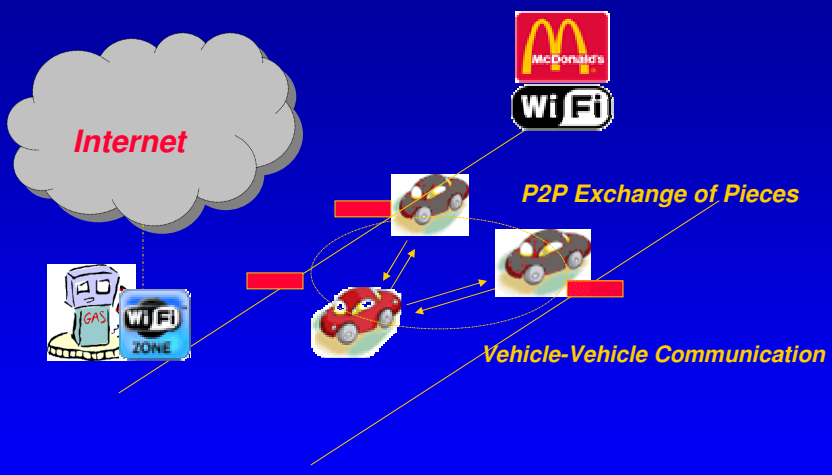
Observation: ***many other drivers are interested in download sharing (like in the Internet)***

Solution: ***Co-operative P2P Downloading via Car-Torrent***

Partial download from Infostation



Co-operative P2P Download

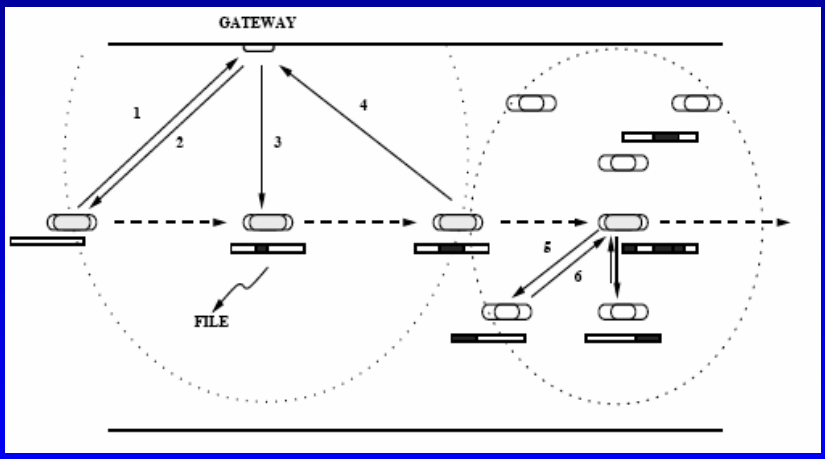


Experimental Evaluation

SIMULATION PARAMETERS

Parameter	Value
λ(Inter-Arrival Time)	0.5-4 seconds
File Size	5MB
Piece Size	64KB
Velocity	40-80 mph
T_c(Gateway Connection Time)	30-60 seconds
Radio Range	100m

CarTorrent: Gossip protocol



A *Gossip message* containing Torrent ID, Chunk list and Timestamp is "propagated" by each peer

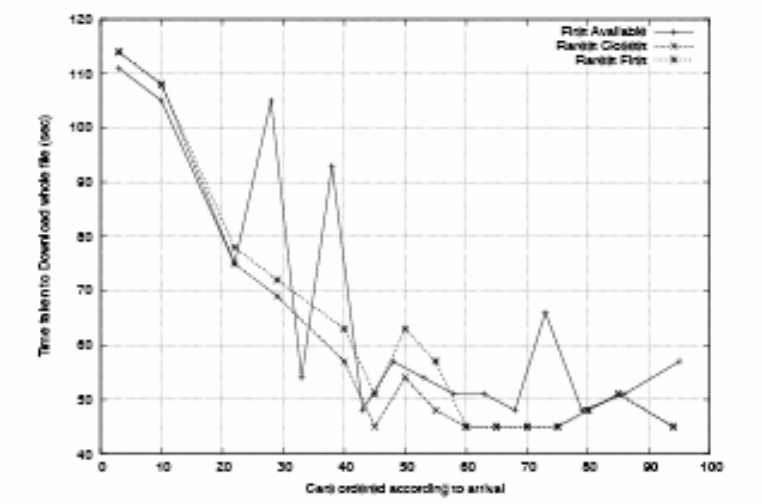
Problem: how to *select the peer* for downloading

Peer Selection Strategies

Possible selections:

- 1) *First Available:* tries to fill the first empty chunk in the bitfield (from low to high)
- 2) *Rarest First:* BitTorrent-like policy of searching for the rarest bitfield in your peerlist and downloading it
- 3) *Rarest Closest:* weighs the rare pieces based on the distance to the closest peer who has that piece.

Impact of Selection Strategy



Why is the Car-Torrent solution attractive?

- Bandwidth at the infostation is limited and "not convenient"
  - It can become congested if all vehicles stop
  - It is a nuisance as I must stop and waste time
- GPRS and 3G bandwidth is also limited and expensive
- The car to car bandwidth on the freeway is huge and practically unlimited!
- Car to car radios already paid for by safe navigation requirement
- CarTorrent transmissions are reliable - they involve only few hops (proximity routing)

AdTorrent: Digital BillBoards for Vehicular Networks

V2V COM Workshop
Mobiquitous 2005

Alok Nandan, Shirshanka Das
Biao Zhou, Giovanni Pau, Mario Gerla

Digital Billboard

Safer : Physical billboards can be distracting for drivers

Aesthetic : The skyline is not marred by unsightly boards.

Efficient : With the presence of a good application on the client (vehicle) side, users will see the Ad only if they actively search for it or are interested in it.

Localized : The physical wireless medium automatically induces locality characteristics into the advertisements.

Digital Billboard

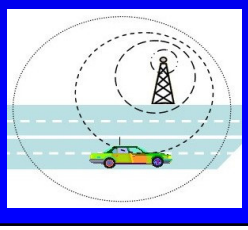
- **Every Access Point (AP) disseminates Ads that are relevant to the proximity of the AP**
- **from simple text-based Ads to trailers of nearby movies, virtual tours of hotels etc**
- **business owners in the vicinity subscribe to this digital billboard service for a fee.**
- **Need a location-aware distributed application to search, rank and deliver content to the end-user (the vehicle)**

AdTorrent Features

- Keyword Set Indexing to reduce Communication Overhead
- Epidemic Scoped Query Data Dissemination – optimized for vehicular ad hoc setting
- Broadcast medium leveraged for "communication efficiency" of gossip messaging
- Torrent Ranking Algorithm
- Swarming in actual content delivery
- Discourage Selfishness

How about car to car on-line games?

- New Challenges:
  - Frequent changes in packet routing
  - Highly variable latencies
  - Intermittent connectivity
  - Packet losses due to errors
  - Bandwidth shortage



New Research Opportunities

- Lots of research done on ad hoc nets
- Yet, most of it addressed large scale, self standing, military and civilian defense problems
- Opportunistic ad hoc extensions are “small scale”, few hops - must integrate well with infrastructure
- New, research (beyond military) is critical for “opportunistic” deployment:
  - Security, privacy
  - Reward Third Party forwarding; prevent “cheating”
  - Realistic mobility models (waypoint mobility not enough!)
  - Delay tolerant networking
  - P2P protocols; proximity routing - epidemic dissemination

Conclusions

- Opportunistic ad hoc extensions can:
  - Extend reach
  - Reduce access costs
  - Improve fault tolerance
  - Allow better use of available resources
  - Introduce new functionalities (delayed delivery with piggyback rides, file sharing, etc)
- An exciting, emerging scenario is Car to Car networking
- Safety, entertainment, environment monitoring applications
- New research opportunities
- Will become one of the leading application of commercial ad hoc networking