Session II: *Wireless/Mobile/Sensor Network Requirements* - Moderator Mario Gerla

- Wireless Sensor networks for Environmental Monitoring – a Driver for Adaptive and Programmable Network and Distributed System Services (Deborah Estrin)
- Mobile/wireless Networking Scenarios/Requirements (Mario Gerla)
- Thoughts on Requirements Placed on the Network by Mobile Platforms (Kevin Kahn)
- Scaling Wireless Networks (Srinivas Seshan)
- Near-Field Networks (Badri Nath)
- Wireless/sensor net security (Wade Trappe)
- Interfacing embedded sensor networks to the Internet (Phil Levis)
- Discussion time

What is this session all about?

- Identify new requirements placed by wireless users on the Internet “network layer”
- These new requirements may trigger a “redesign” of the IP stack (or more generally the way we do networking)
- We are not concerned with SOLUTIONS at this point (it is the job of Session III speakers)
- Questions to be addressed:
  - What is the wireless scenario/application you are addressing?
  - What is the problem to be solved?
  - What are the new qualitative requirements on the network layer?
  - What is the impact of these innovations on user performance?

Outline of my talk

- **Wireless scenarios that drive new requirements**
  - Opportunistic ad hoc networking
  - Car to car environment
- **The network layer functions**
- **Upper/lower layer impact through cross-layering**

Wireless Scenarios

1. Internet access: cellular (2, 2.5, 3G), wireless LANs, mesh networks
2. “Opportunistic” Ad hoc extensions of the above (eg, vehicle networks)
3. Self standing ad hoc networks (eg, disaster recovery, battlefield)
4. Sensor/actuator/robot networks
5. Pervasive computing networks, which provide user/environmental sensor interaction

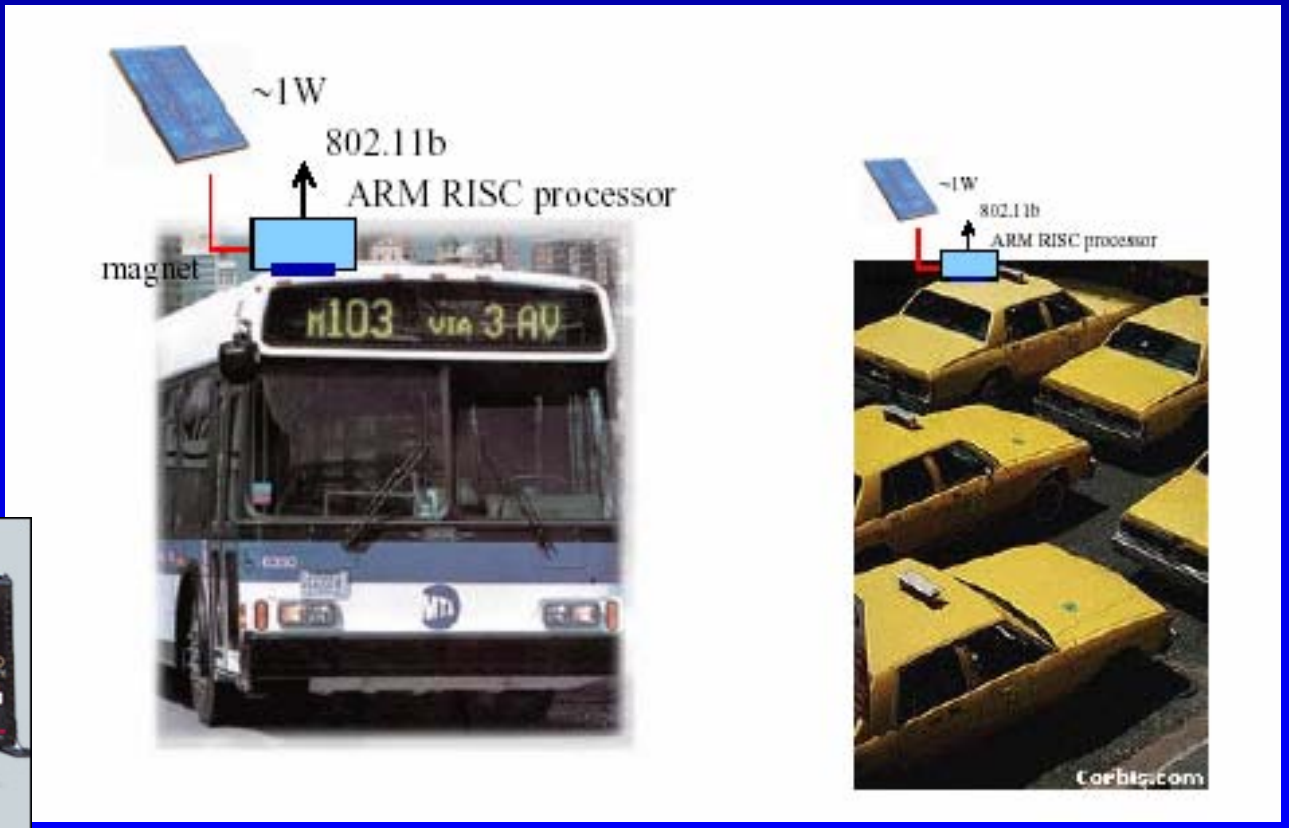
What is an opportunistic ad hoc net?

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

Opportunistic piggy rides in the urban mesh

Pedestrian transmits a large file in blocks to passing cars, busses

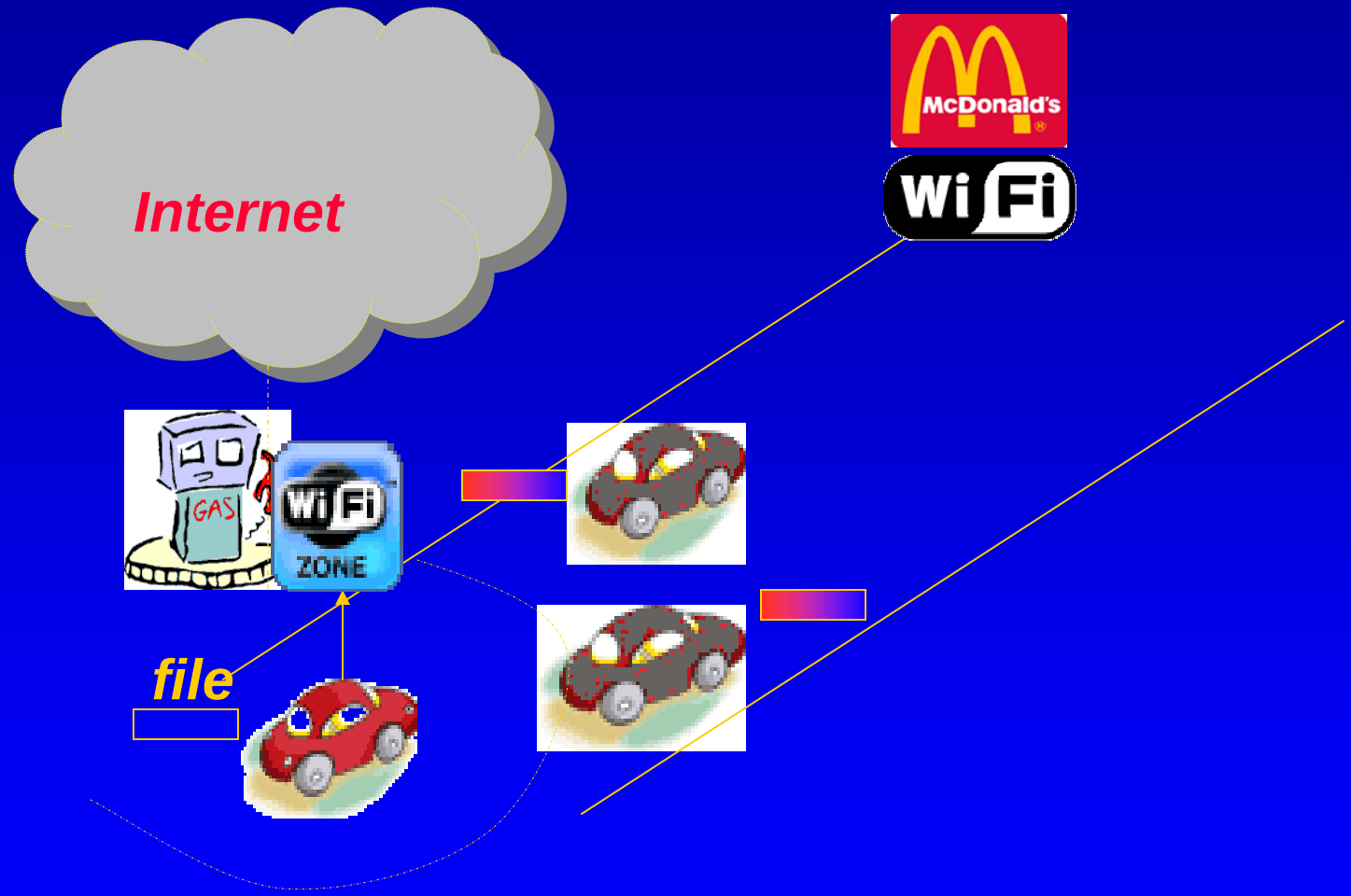
The carriers deliver the blocks to the hot spot



CarTorrent : Opportunistic Ad Hoc networking to download large multimedia files

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:

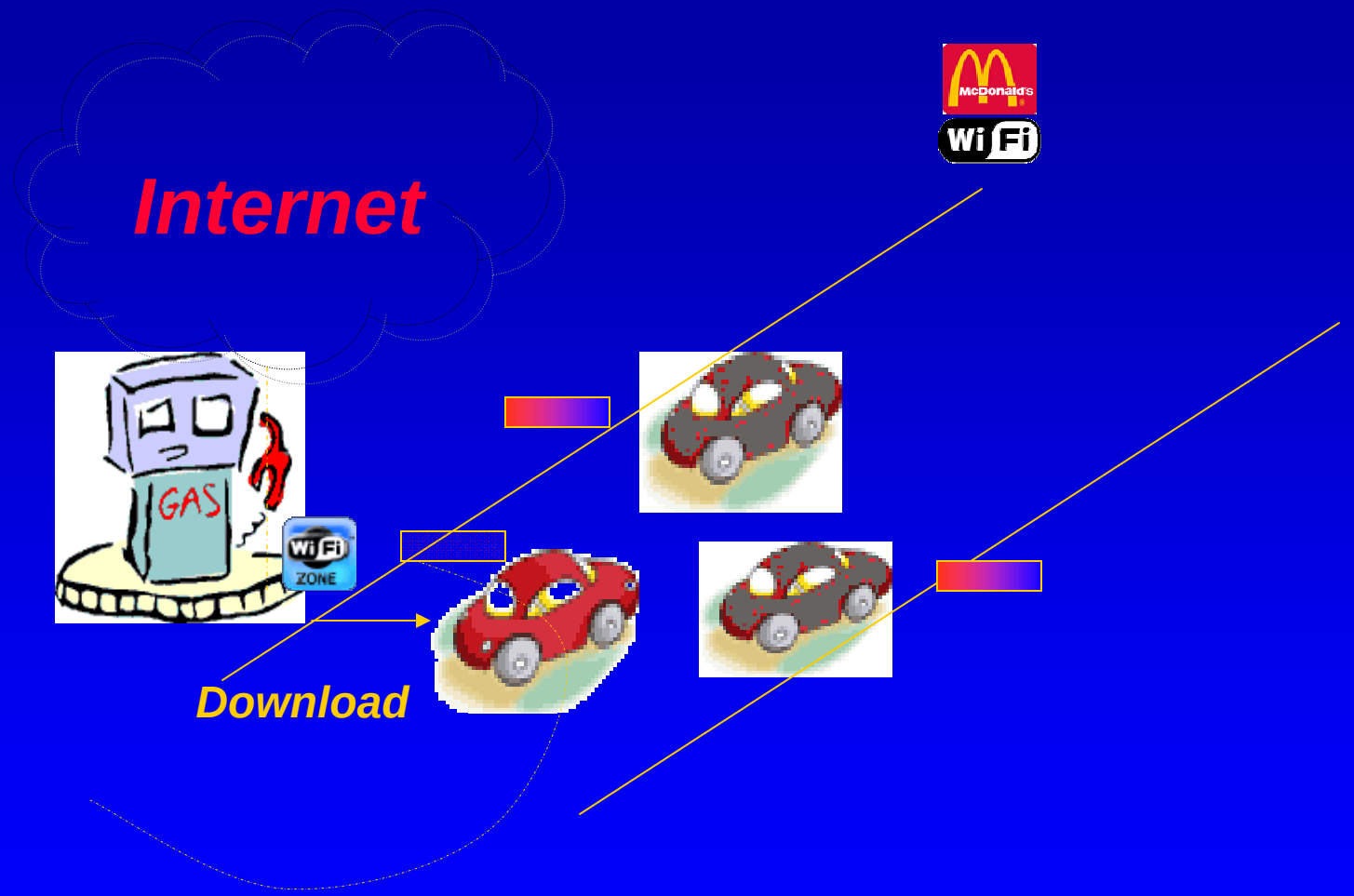
Stopping at gas station to download is a nuisance

Downloading from GPRS/3G too slow and quite expensive

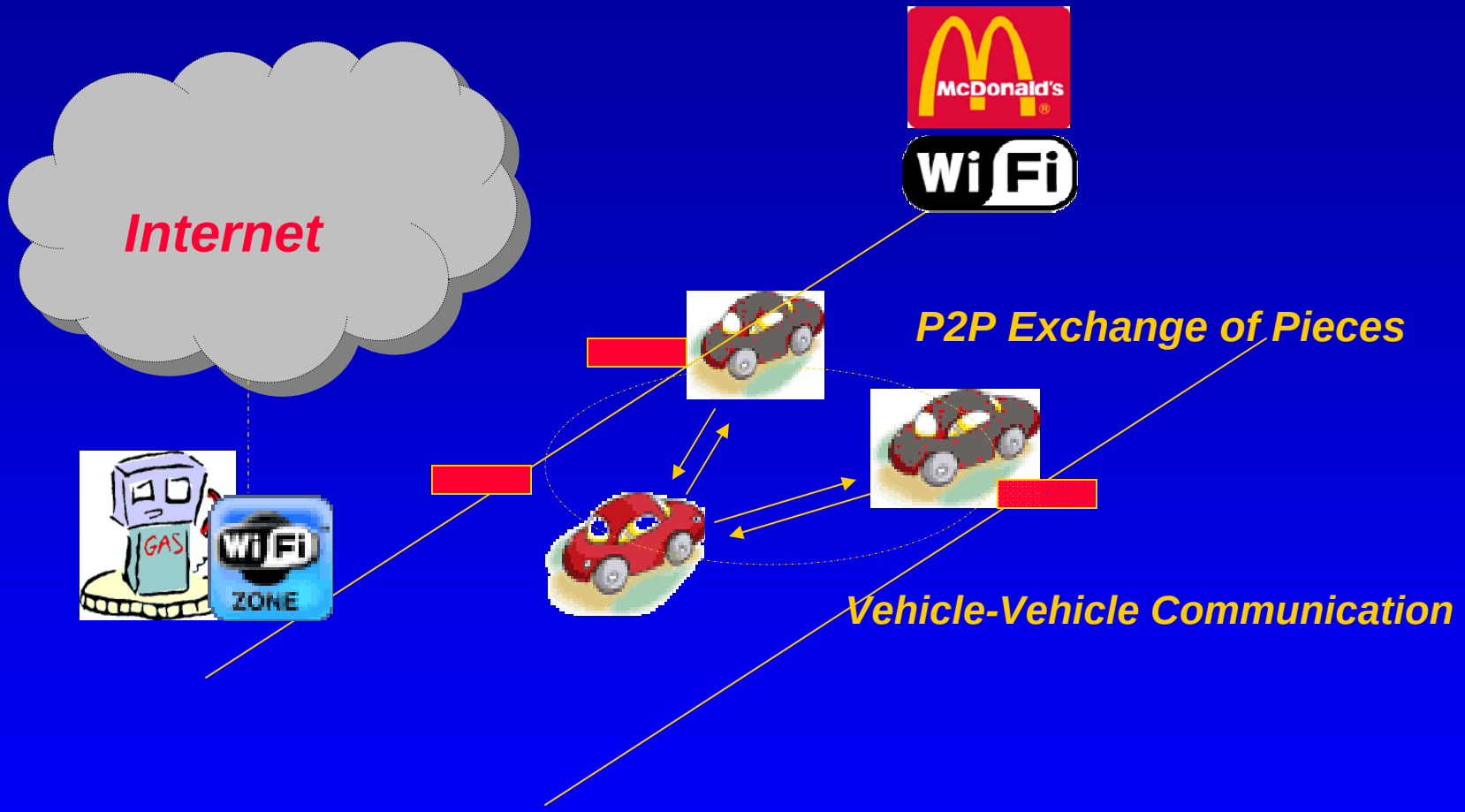
Observation: many other drivers are interested in download sharing (like in the Internet)

Solution: Co-operative P2P Downloading via Car-Torrent

Partial download from Infostation



Co-operative P2P Download



Why is the Car-Torrent “opportunistic” 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 by safe navigation requirement**
- **CarTorrent transmissions are reliable - they involve only few hops (proximity routing)**

Car Torrent new network demands

- **Routing:**
  - conventional routing when interfacing the Internet at infostation
  - Location aware, content routing in ad hoc mode
  - Delay tolerance policies
  - User control
- **Address “re-binding” when switching from infostation to ad hoc mode**
- **Mobility tracking by server (possibly based on motion prediction)**
- **Incentive policies**
- **Security, trust**
- **etc**

Functions of the network layer

- Addressing; address binding ; mobility management
- Location awareness; Presence; resource discovery; name servers
- Routing
  - **by routable address, by content, by attribute etc**
  - **User controlled routes; multipath routing; delayed delivery (DTN)**
  - **Multicasting; anycasting, etc**
- Congestion control; congestion monitoring (eg, LCN)
- QoS support; scheduling; Packet filtering, priority assignment
- Path measurements, monitoring (eg, Path bandwidth/capacity estimation as in CapProbe, Pathrate etc); error monitoring;
- Network Management (of resource allocation; etc)
- Security, privacy
- Billing; pricing structure; economics

Not all the above is implemented today in the Internet network layer ("narrow waist" design principle)

What about other layers' impact on IP?

Cross layer interaction:

- Lower layer inputs to network layer:
  - path has broken, path capacity has decreases, congestion (eg, LCN); mobility prediction; mobility pattern detection; link errors; jamming
  - Require IP feedback to source
- Upper layer inputs to network layer:
  - Application performance demands (which become requirements for the IP layer); eg, proxies to transcode; low jitter for VoIP, etc
  - classification by traffic -> customized handling at network layer

Let’s go and get those requirements out!

Thanks!