MV-MAX

Which would you prefer: Fairness or Throughput for Multi-Vehicular Communication

David Hadaller
Srinivasan Keshav
Tim Brecht

David R. Cheriton School of Computer Science
University of Waterloo, Ontario, Canada

Application Scenario

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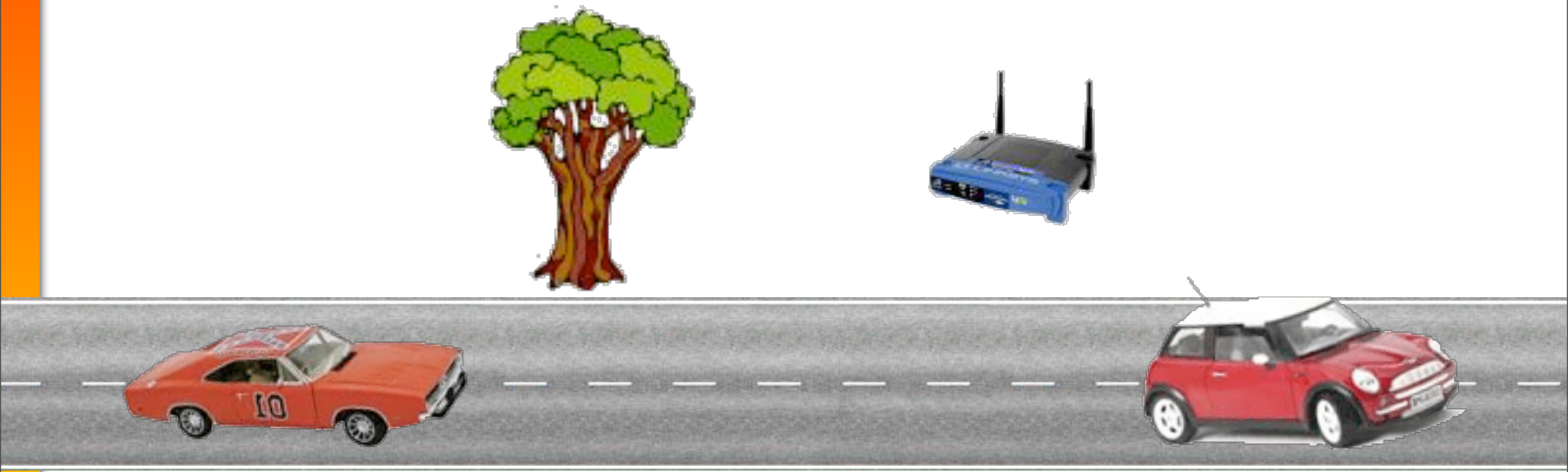

Multiple vehicles in range of a roadside access point

(Counter?) Intuitive

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- Is fairness all it's cracked up to be?

Application Scenario

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- Extreme case of mobile Internet access:
  - Vehicular users (passengers) on the highway
- Applications
  - Rich media (e.g. football highlights)
  - Location-specific travel information
    - Catered to user preferences
    - "Welcome to Cambridge" mp3 advertisement
  - Unload digital camera

Bulk Data on the Road?

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- These needs can be met by a mix of:
  - Faster cell service (3G, 4G)
  - WiFi on the road
- WiFi is cheap and fast but small coverage
  - Can be used to supplement "always-on" cell service
  - Requires new ***opportunistic*** mode of access
    - Users batch requests
    - Access point acts as a cache

WiFi Potential

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- Single vehicle experiments:
  - 15 MB of bulk TCP data per pass at 100 km/h using 802.11b [Hadaller 2005]
    - 8.5 MB with no external antenna [Gass 2006]
  - 70 MB using 802.11g [Ott 2005]

[Hadaller2005] D. Hadaller, H. Li, and L. G. A. Sung. Drive By Downloads: Studying Characteristics of Opportunistic Connections. In USENIX NSDI Poster Session, 2005.

[Ott2005] J. Ott and D. Kutscher. A Disconnection-Tolerant Transport for Drive-thru Internet Environments. In IEEE INFOCOM, 2005.

[Gass2006] R. Gass, J. Scott, and C. Diot. Measurements of In-Motion 802.11 Networking. In IEEE Workshop on Mobile Computing System and Applications (HOTMOBILE), 2006.

Example Coverage Area

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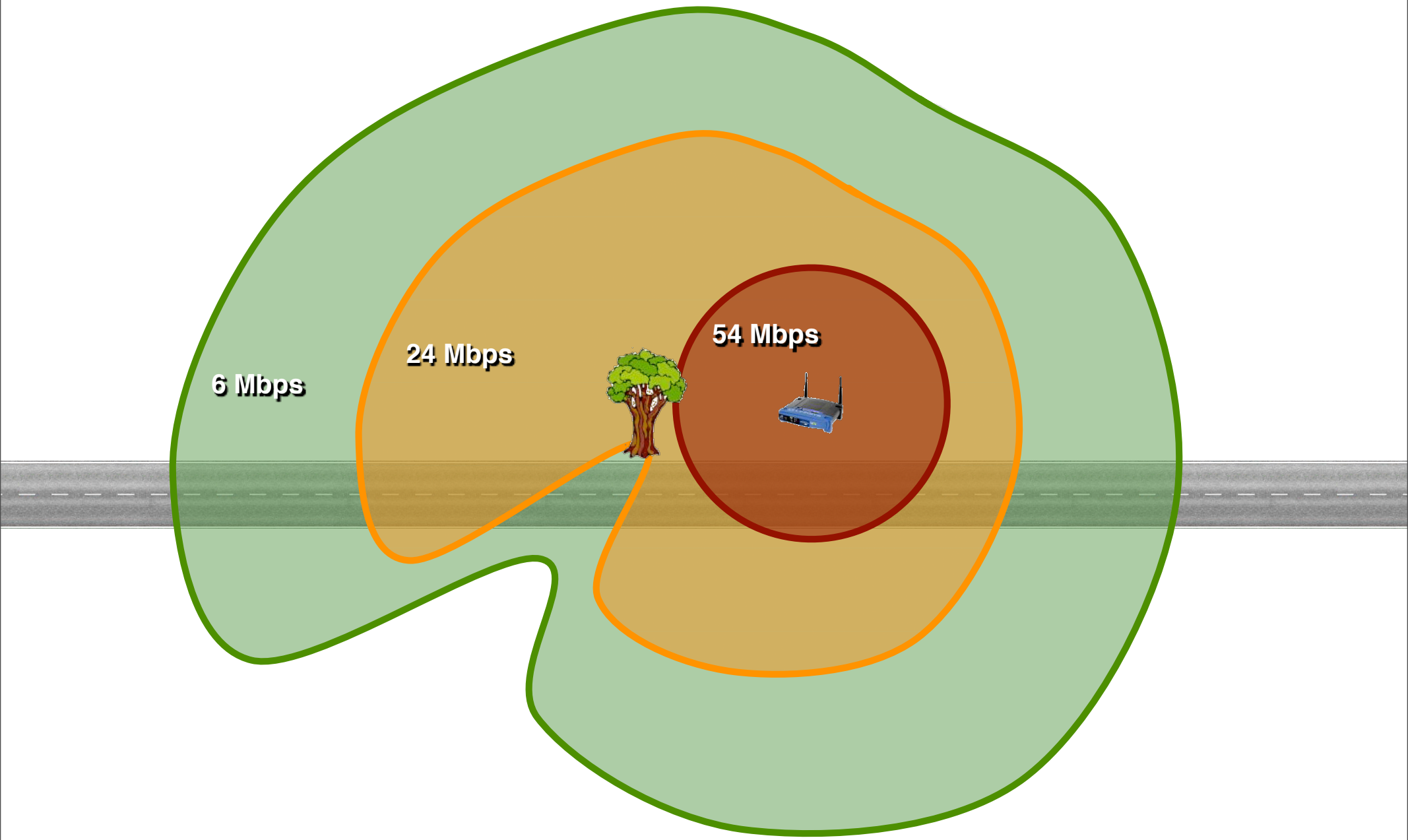
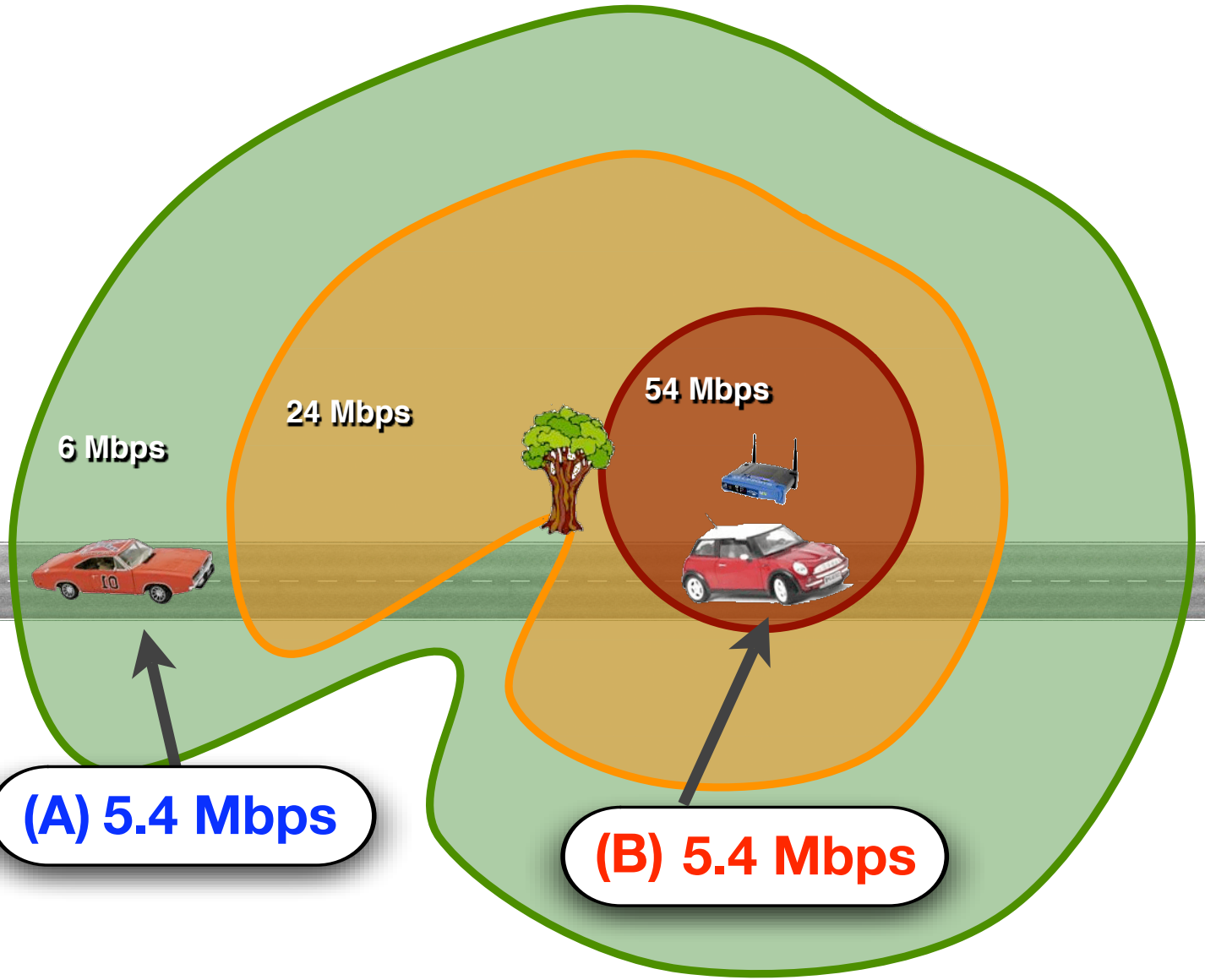


Example Scenario: 802.11



System Rate

802.11

10.8 Mbps

Time Fairness

MV-MAX

Medium usage with shown vehicle positions (802.11 MAC Scheduling):

Example Scenario: Time Fairness

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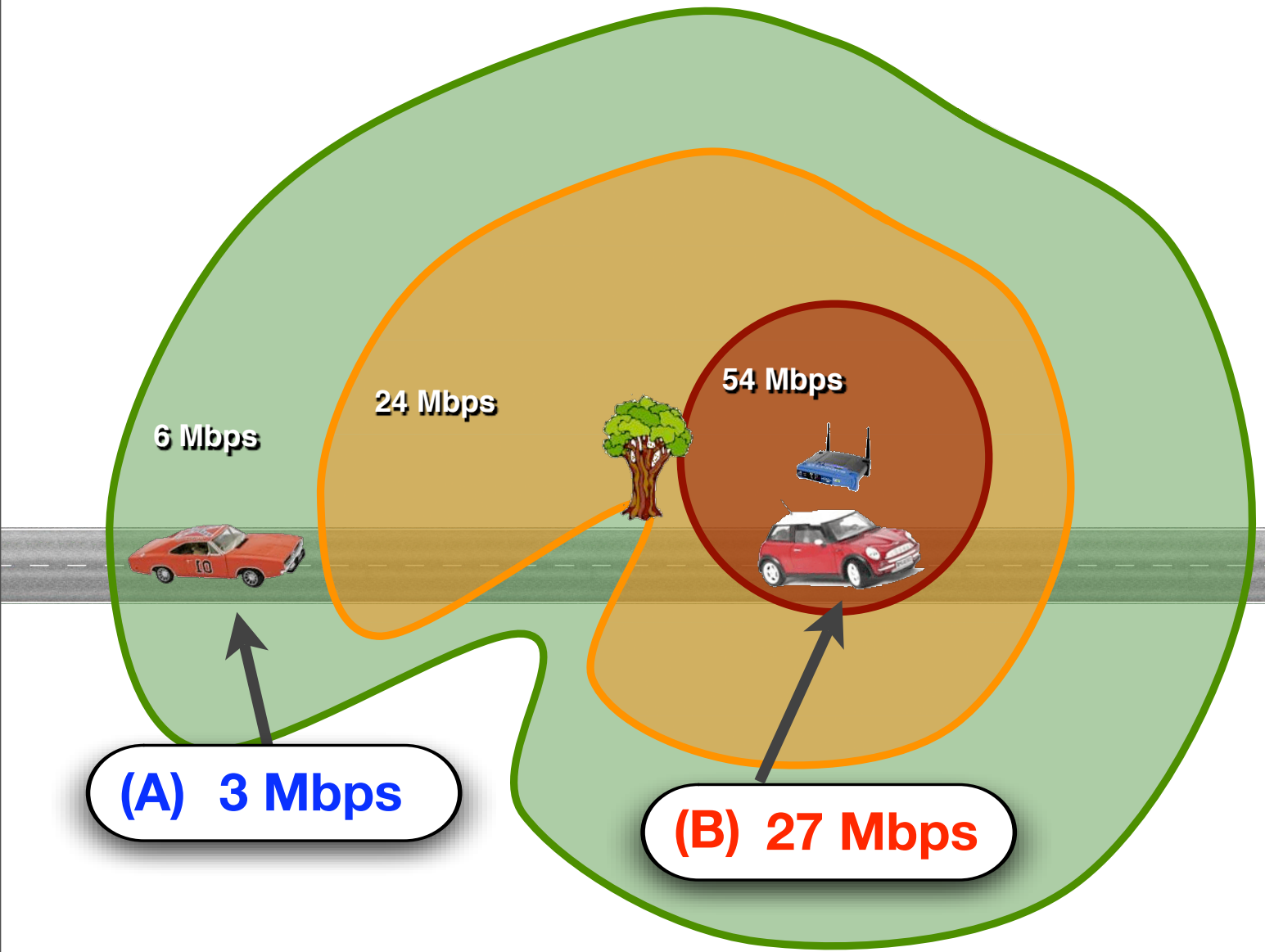

System Rate

802.11

10.8 Mbps

Time Fairness

30 Mbps

MV-MAX

Medium usage with shown vehicle positions (Time Fair Scheduling):

MV-MAX

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- MV-MAX assigns the wireless medium to the user experiencing the best signal quality
  - Intuition: take full advantage of periods of good signal quality
  - Maximizes system throughput
  - But at what cost to user fairness?
    - Premise: all users will eventually experience good signal quality on the highway

Example Scenario: MV-MAX

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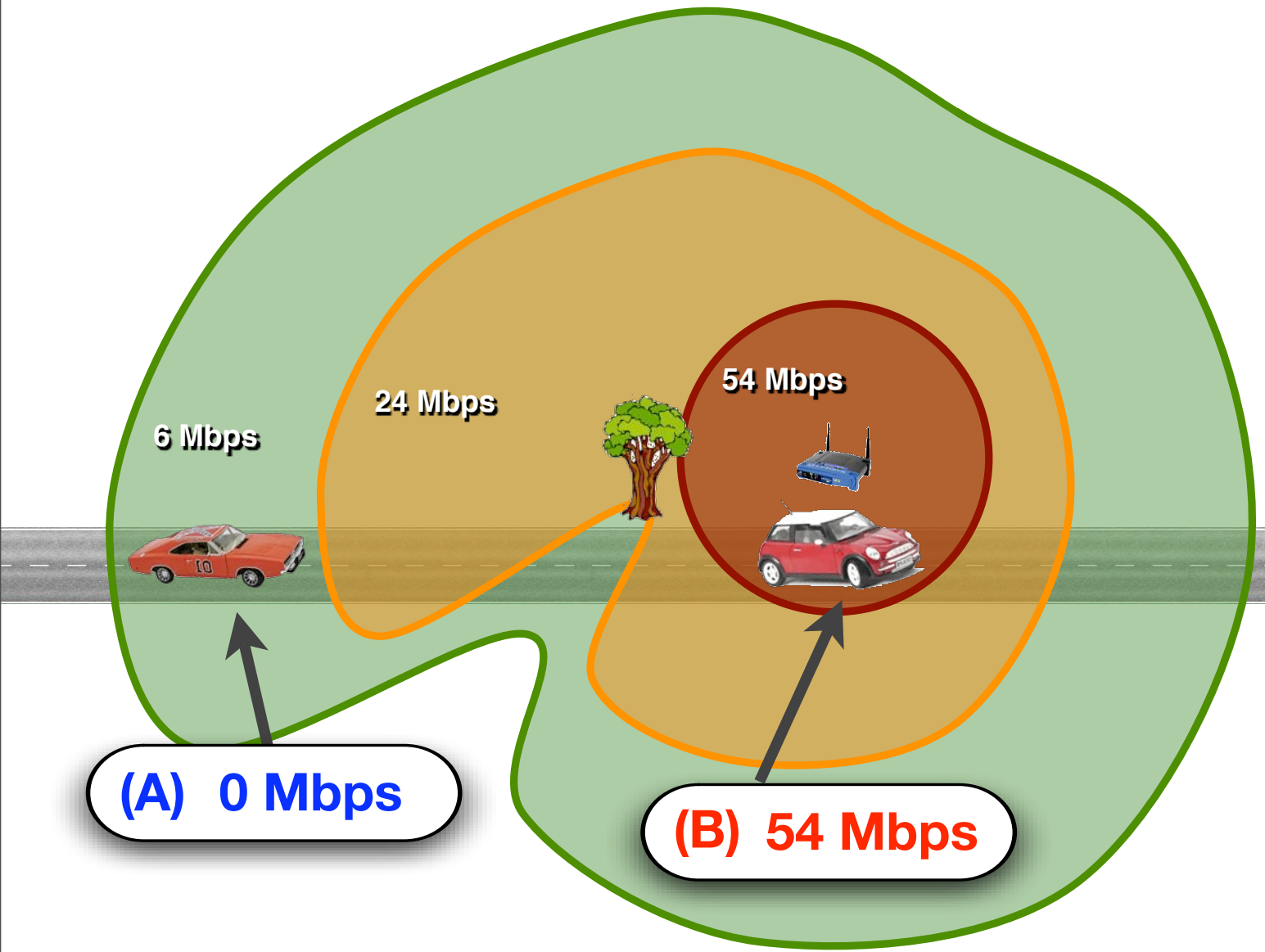

System Rate

802.11

10.8 Mbps

Time Fairness

30 Mbps

MV-MAX

54 Mbps

Medium usage with shown vehicle positions (MV-MAX):

Simulations

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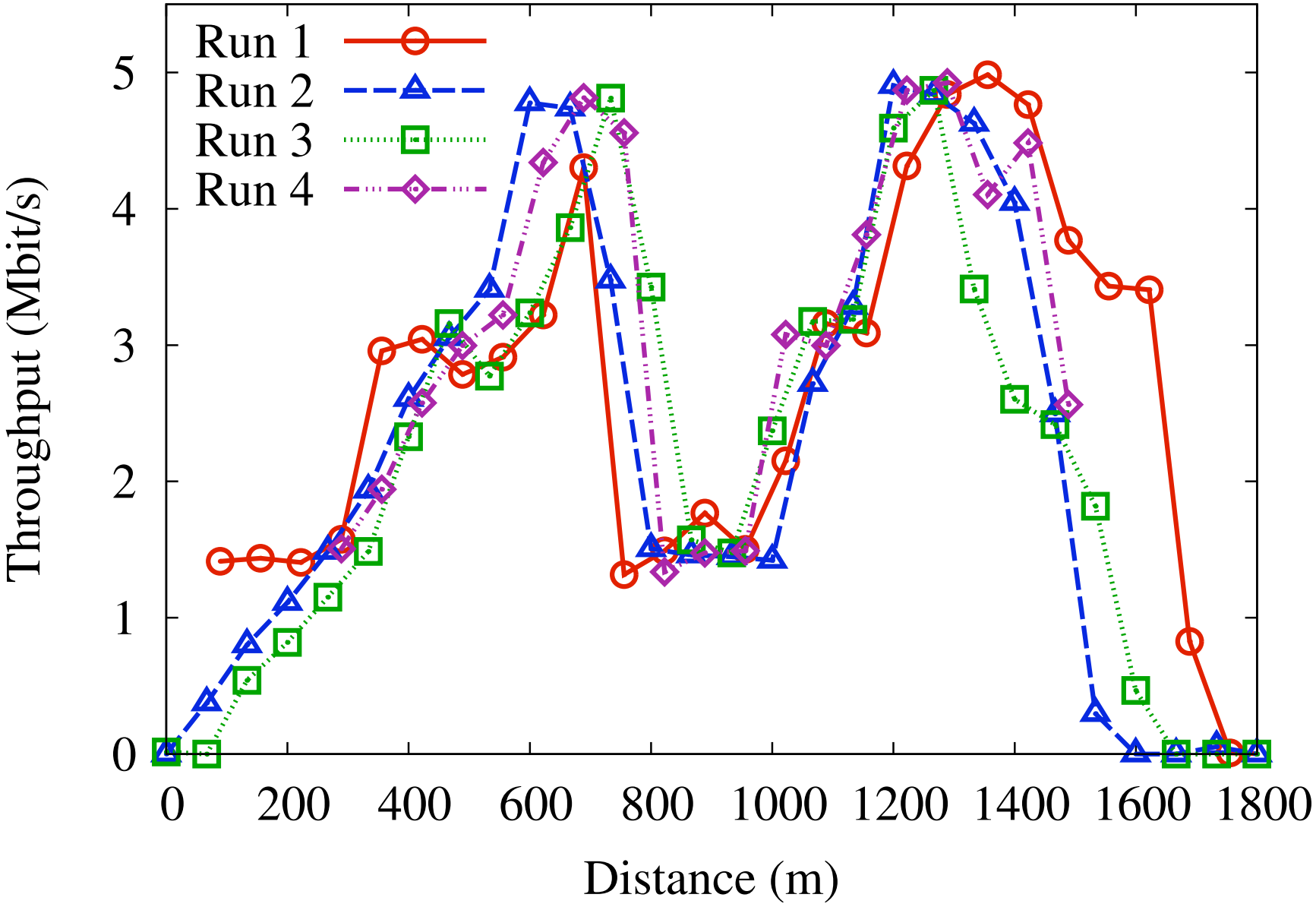
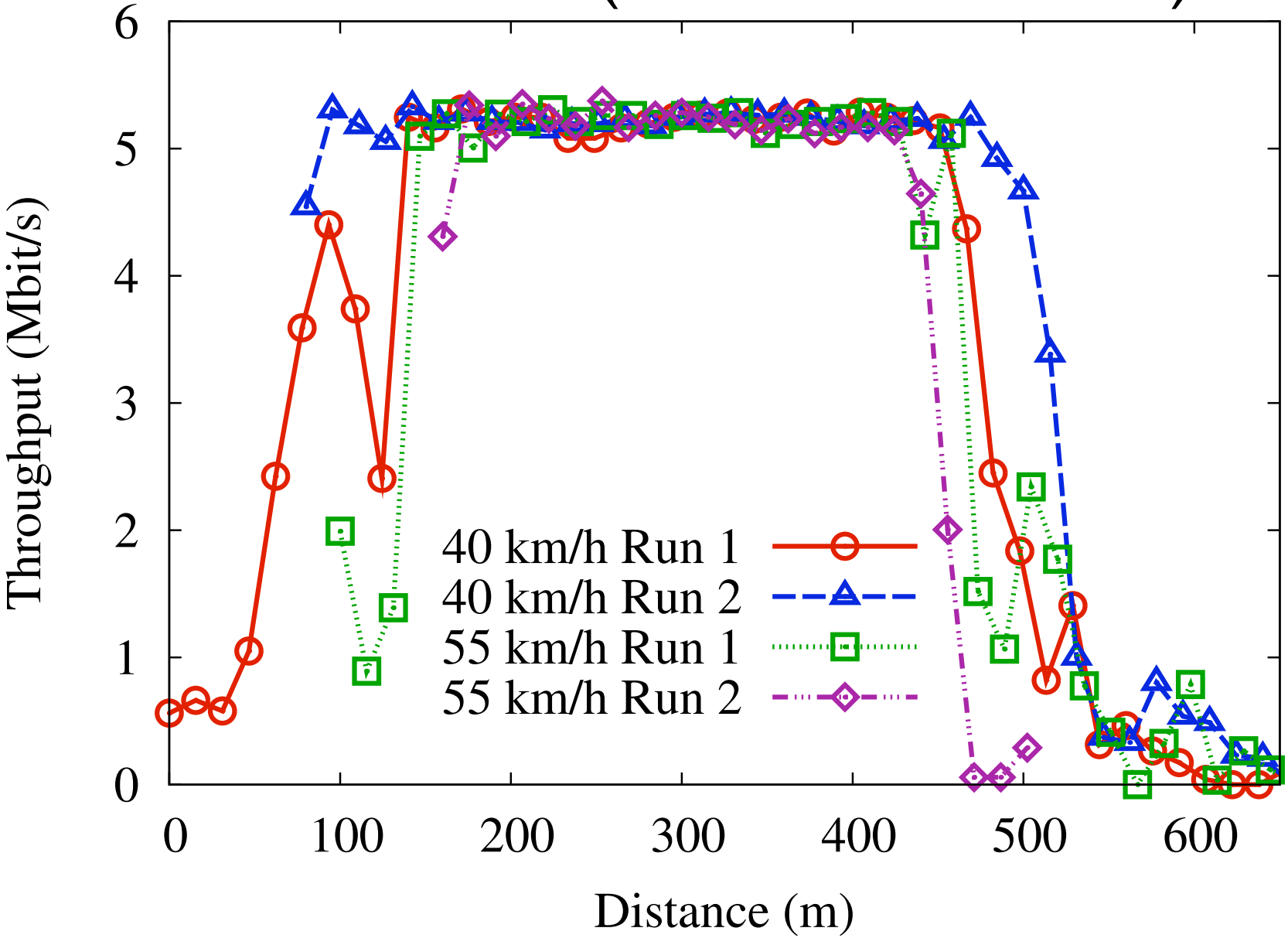
- Is fairness worth it?

Our Data (TCP over 802.11b)



Our data: single vehicle passing an AP [Hadaller 2005]

Intel Data (TCP over 802.11b)



Intel data: single vehicle, no external antenna [Gass 2006]

System Throughput (Our Data)

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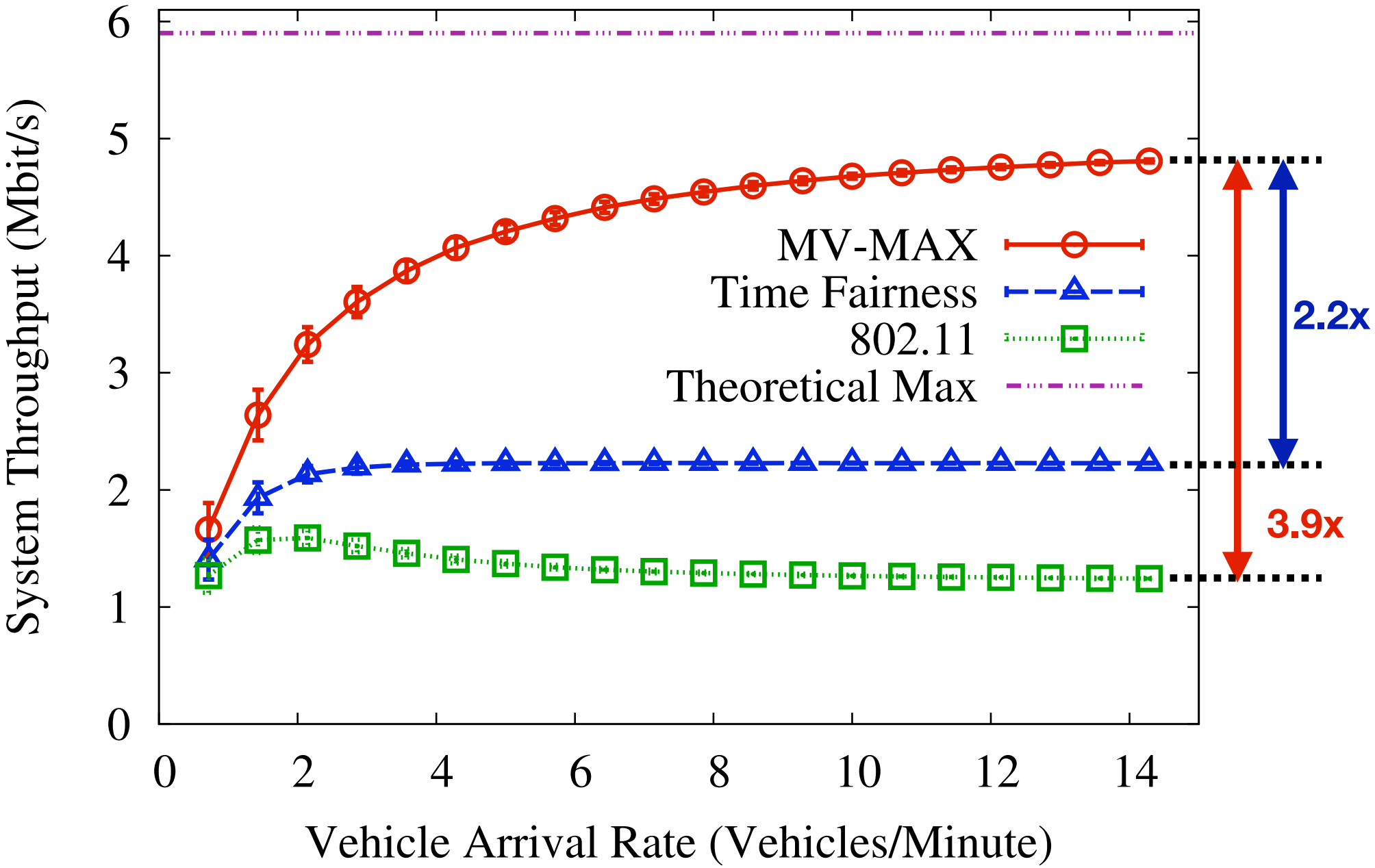

System Throughput

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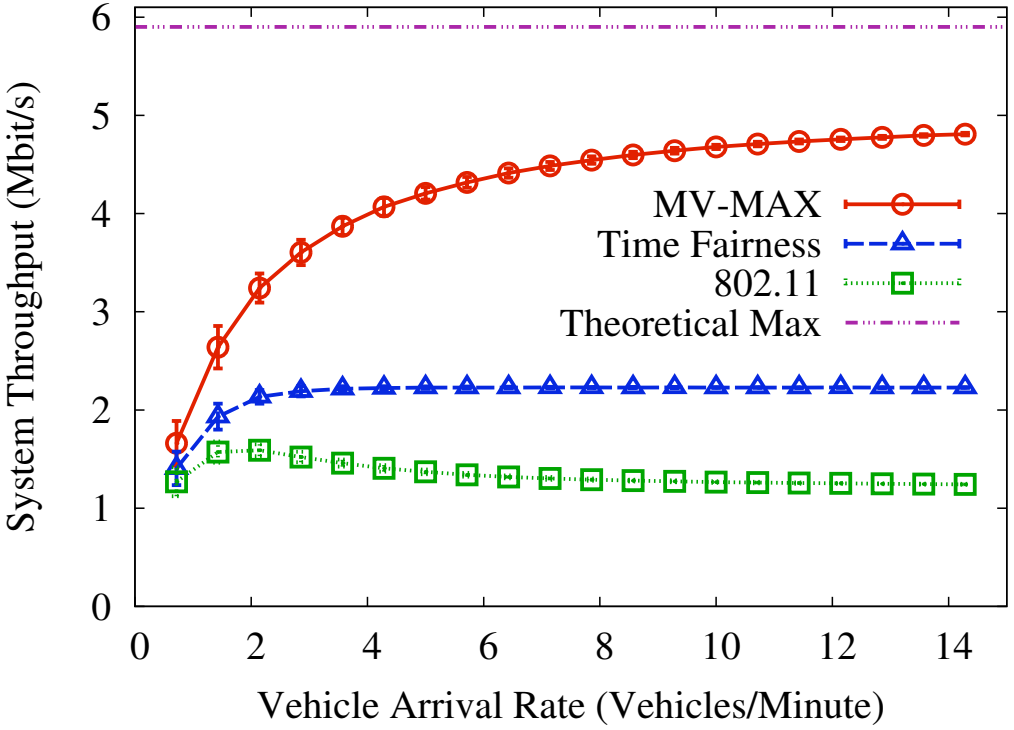
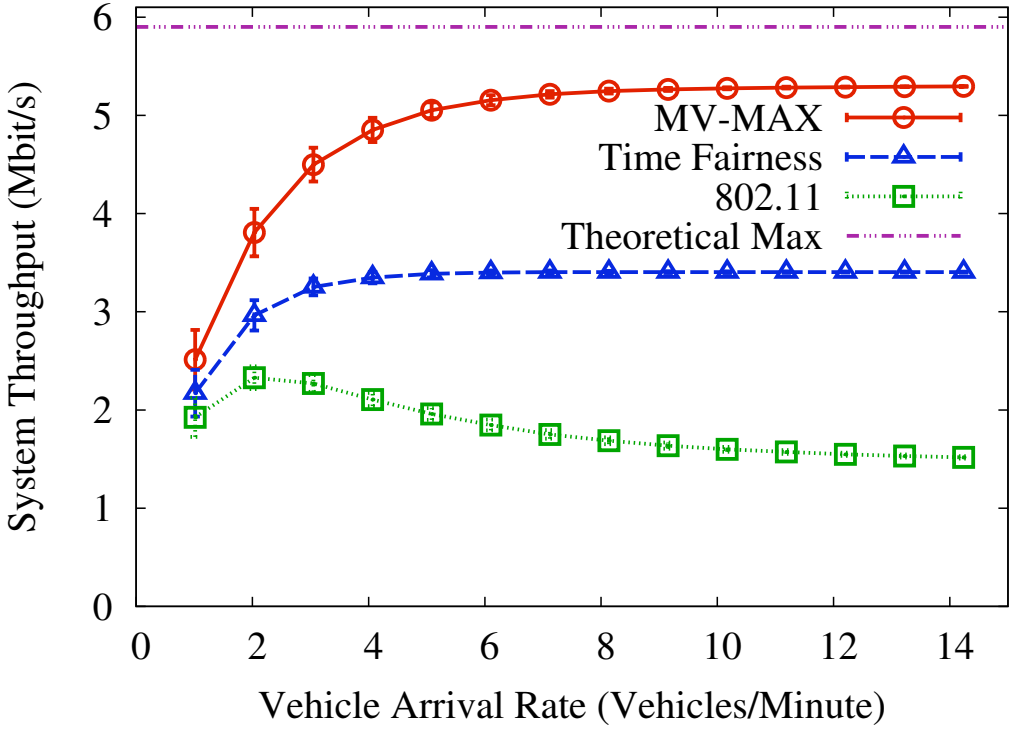


Our Data



Intel Data

Fairness

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- Do some vehicles take a large performance hit?
  - Are some vehicles starved?
- User Experience =~ Amount of Data Transferred
- Per-Vehicle Improvement Ratio
  = Data transferred vs 802.11

Improvement vs. 802.11

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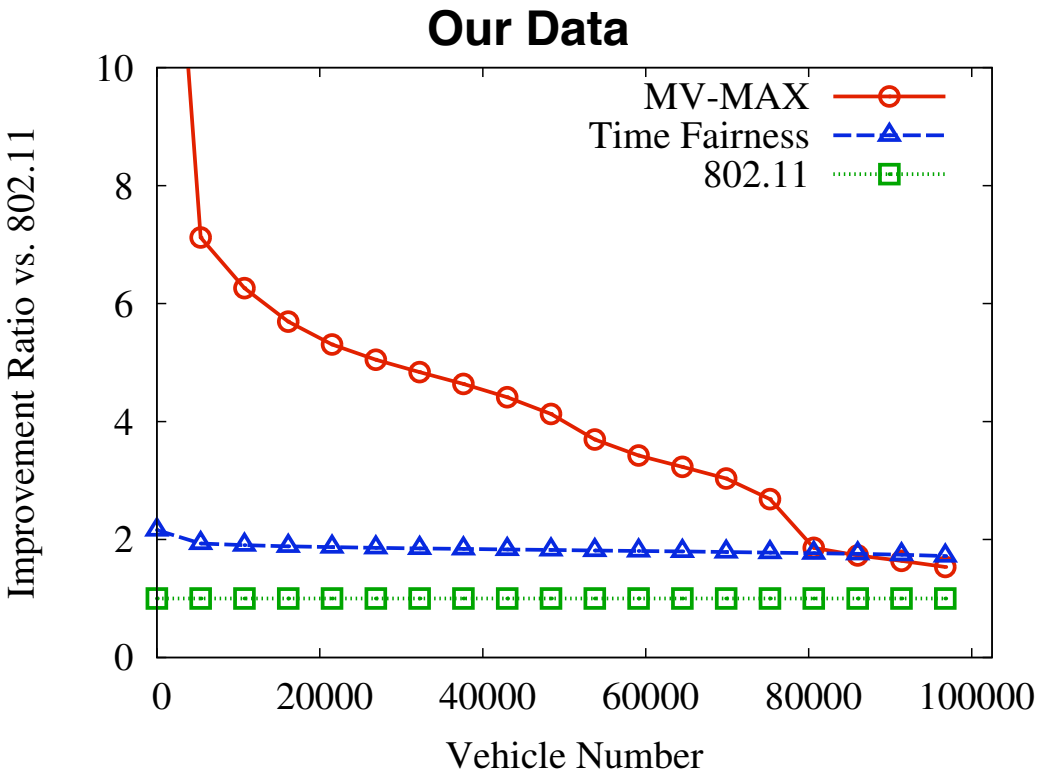

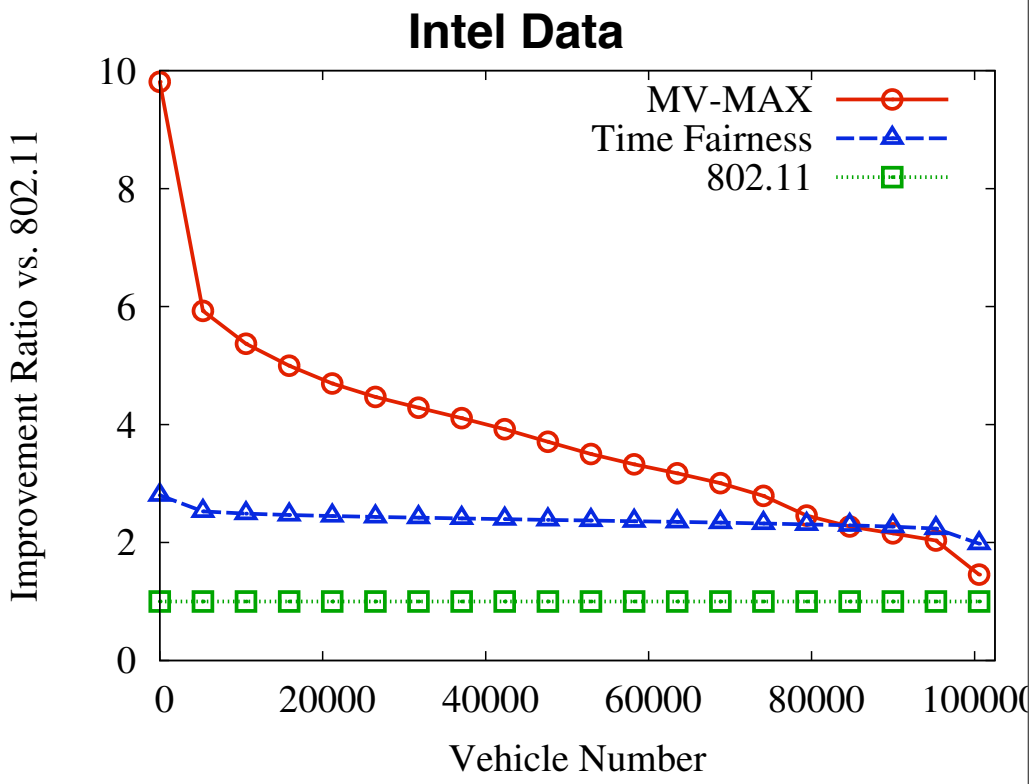

Using either MV-MAX or Time Fairness, compared to 802.11, every vehicle is able to transfer more data.
(dense vehicle traffic)

Lorenz Fairness Curve

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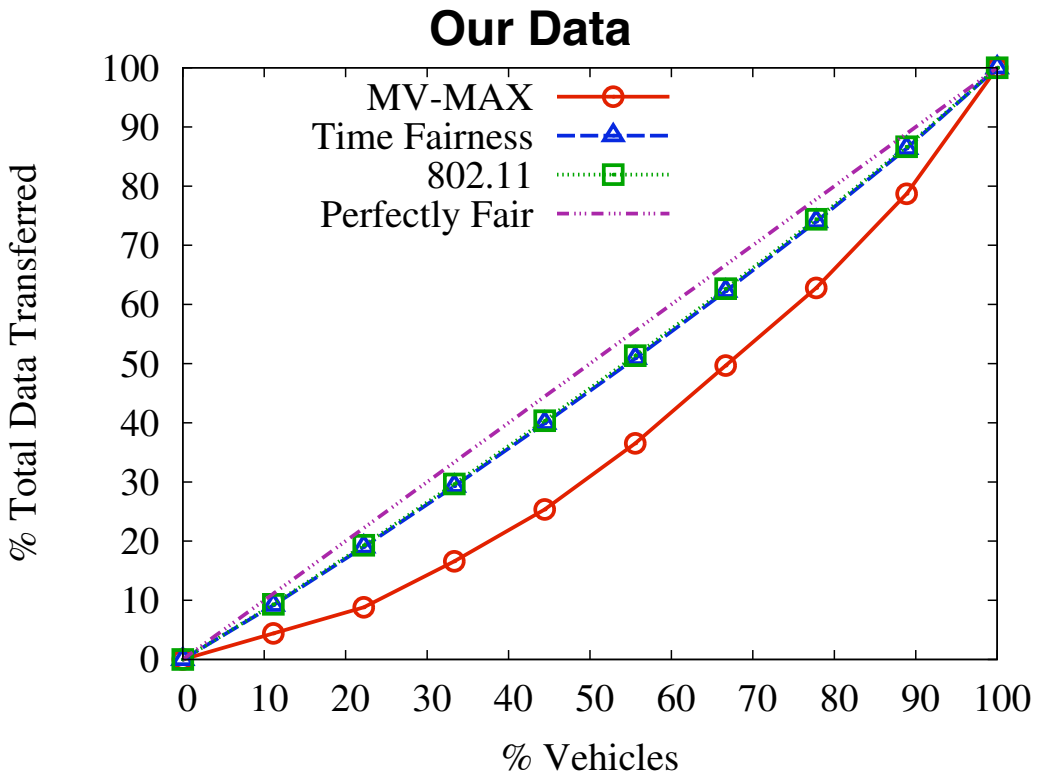

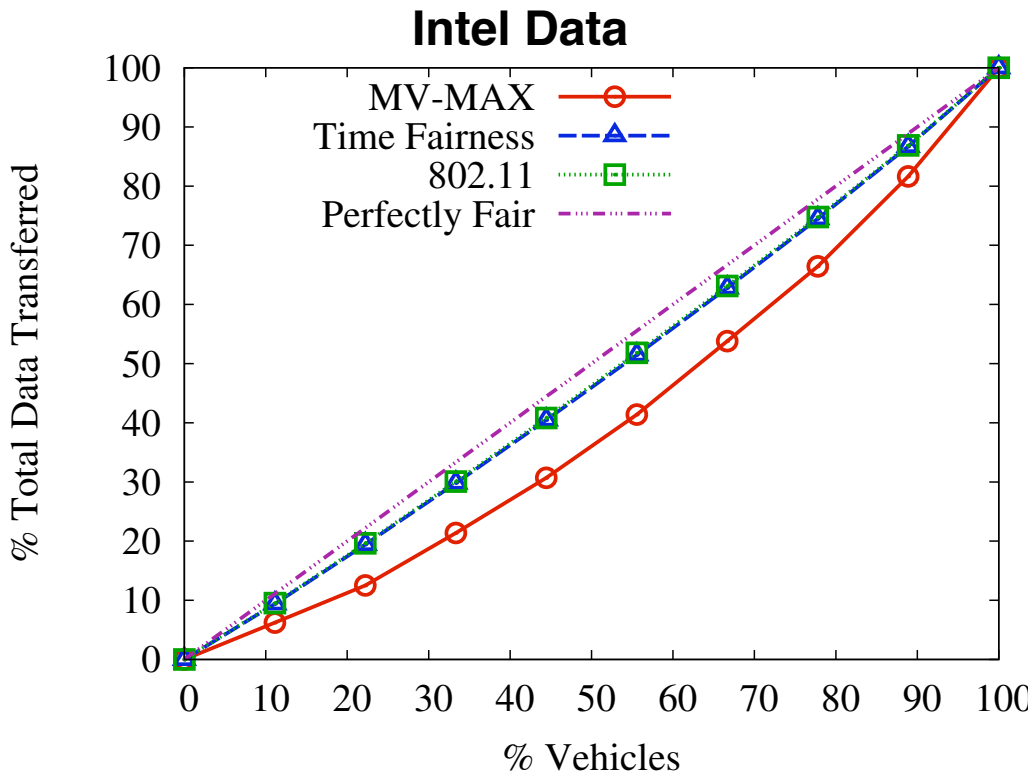

MV-MAX is only marginally less fair.
(dense vehicle traffic)

Why be fair if every vehicle improves?

Sneak Peak: Testing MV-MAX

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Two Vehicles using 802.11b

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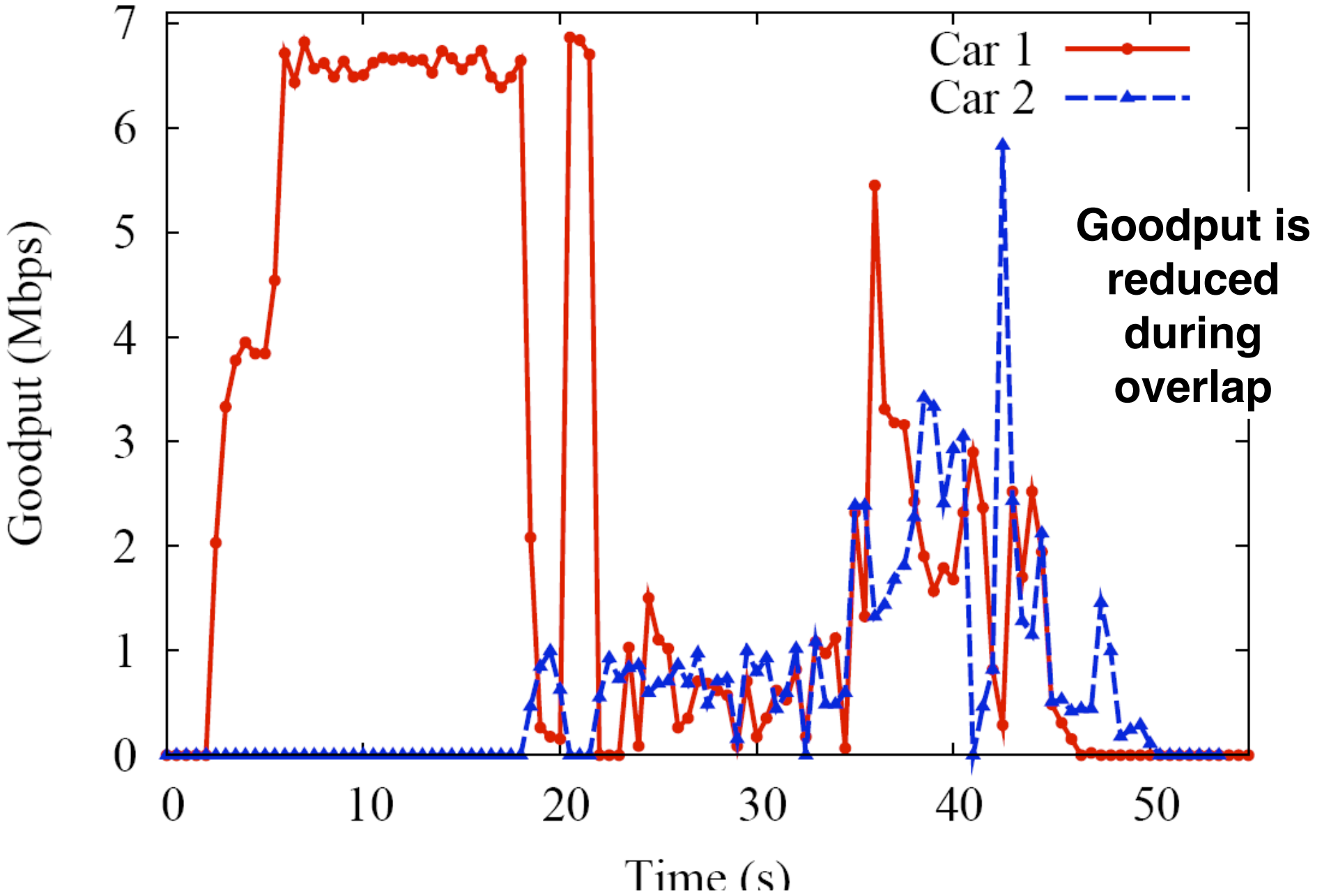

Goodput is reduced during overlap

Two Vehicles using MV-MAX

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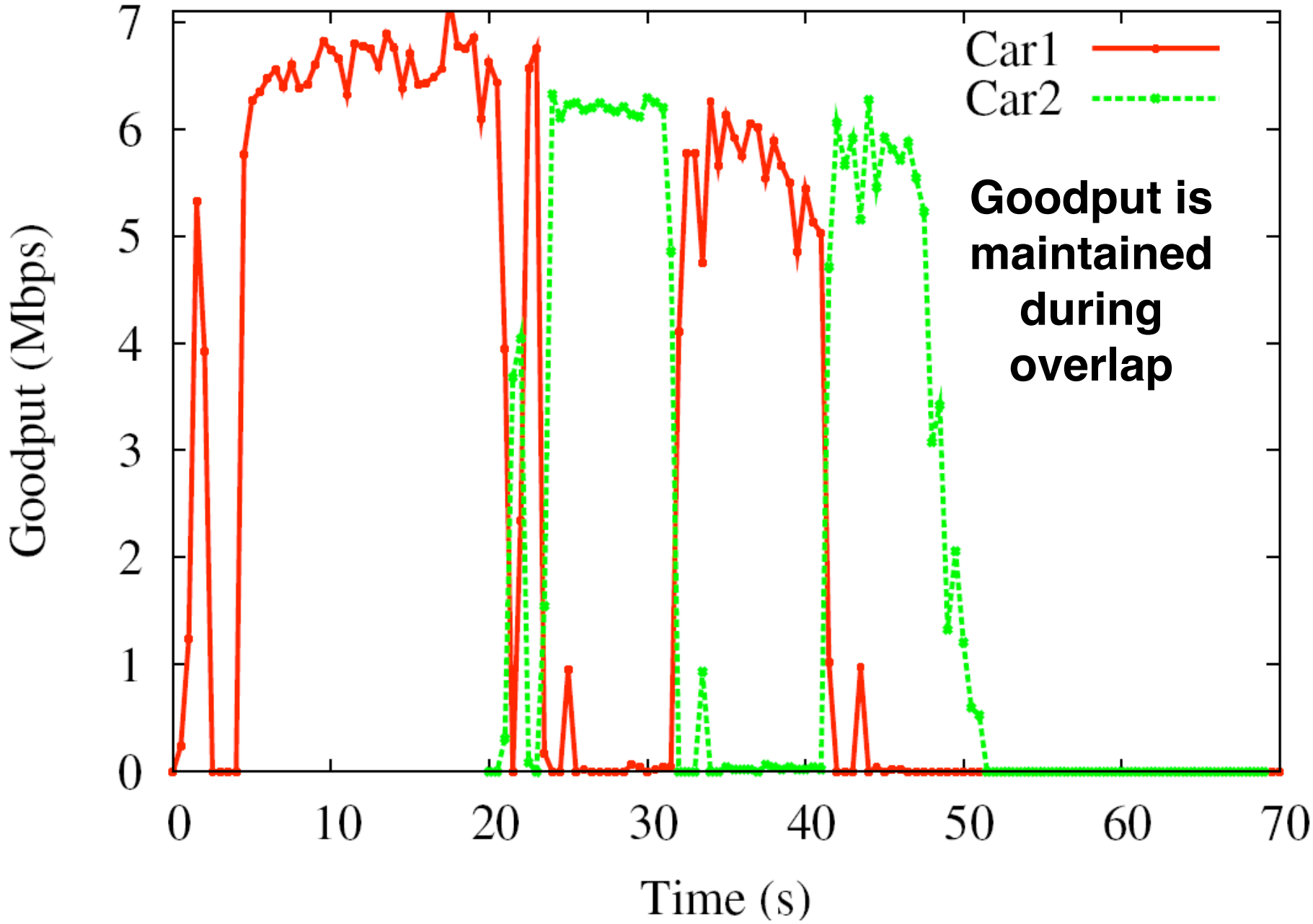

Aggregate Goodput

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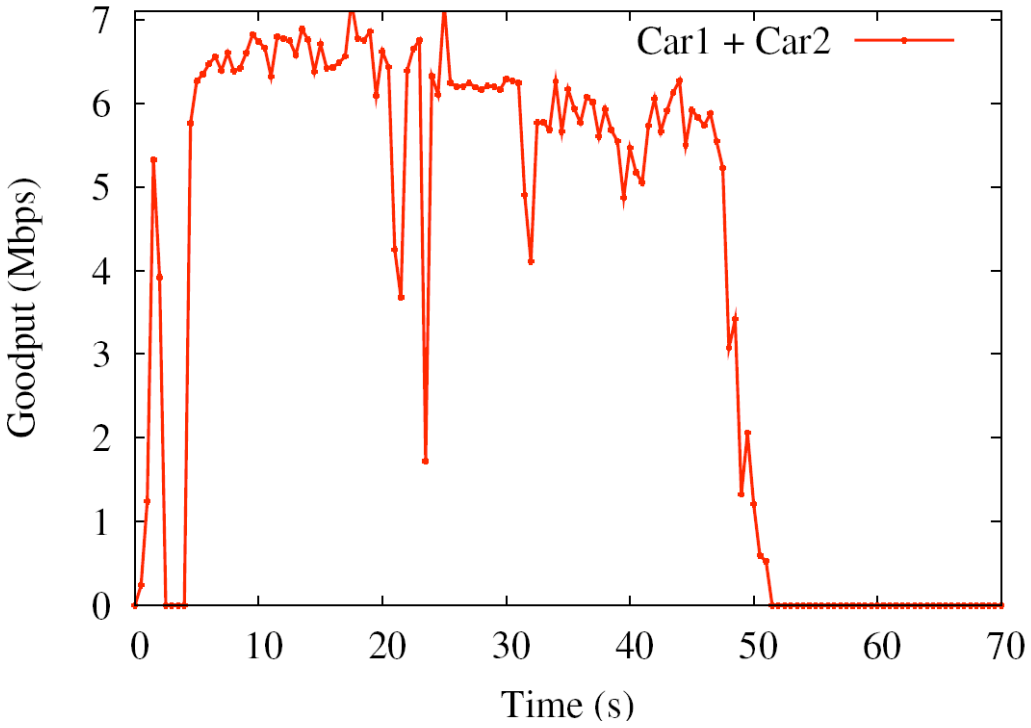
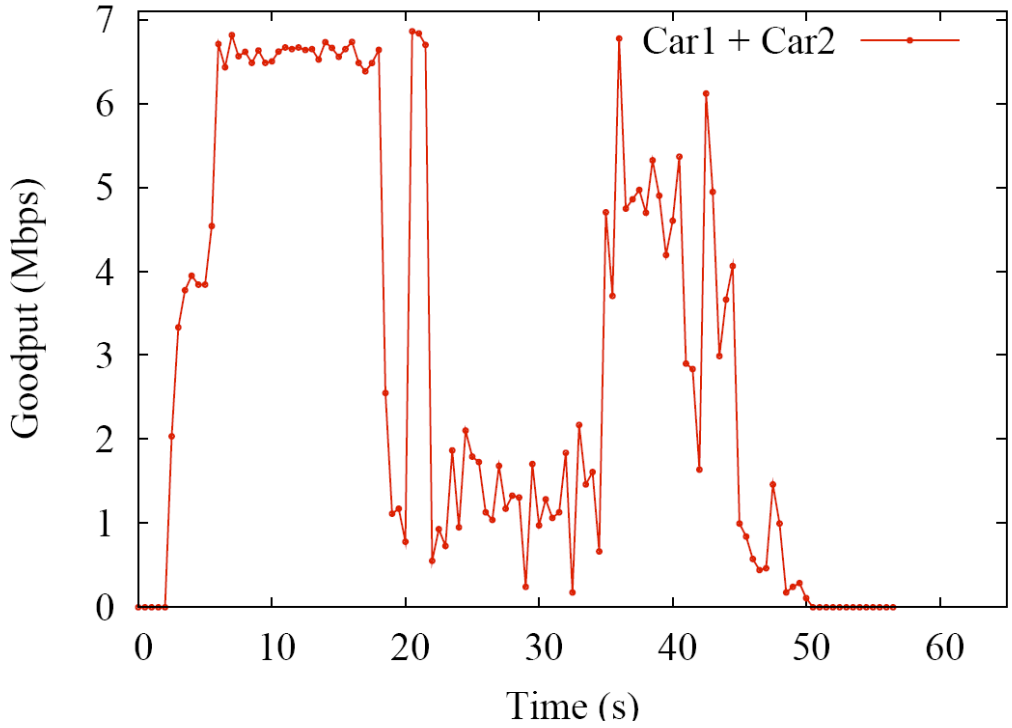


MV-MAX



802.11

Conclusion

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- Attempting to achieve perfect fairness in the multi-vehicular reduces performance
- Significant scheduling gain can be achieved due to repeatable signal patterns
  - MV-MAX improves throughput by up to 4x vs. 802.11, and up to 2x vs. Time Fairness