The role of information in smart transport

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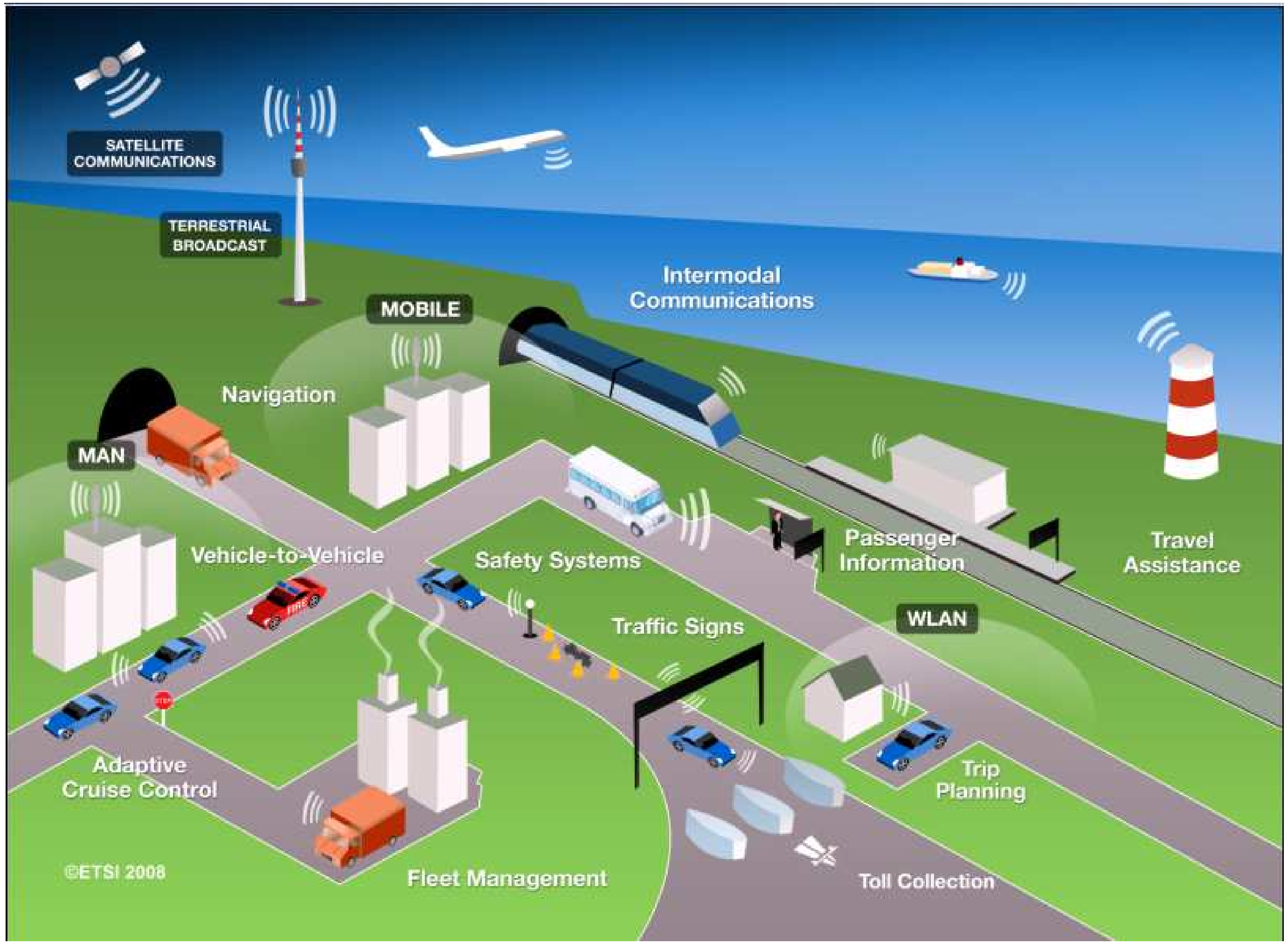
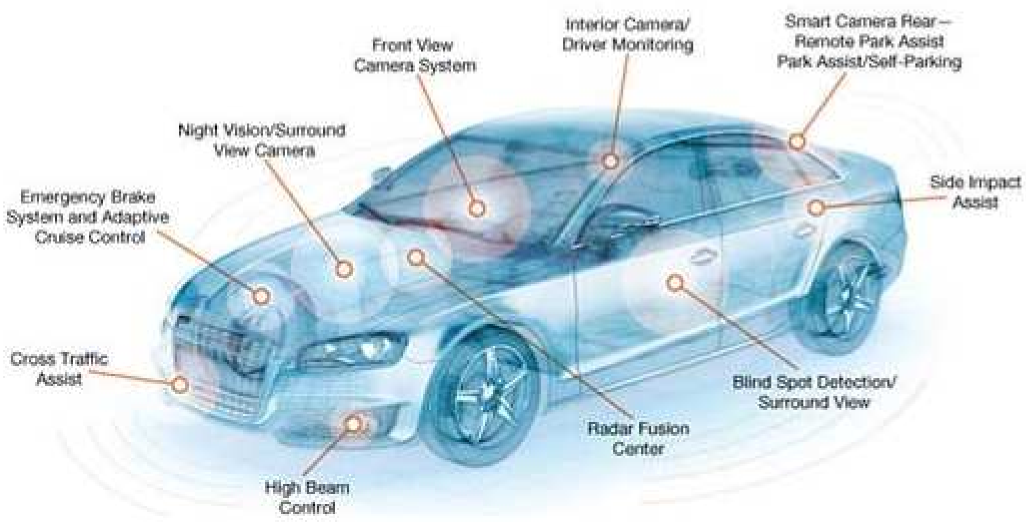
Intelligent Transport Systems (ITS)



Source: www.etsi.org/WebSite/document/Technologies/ETSI-ITS.jpg

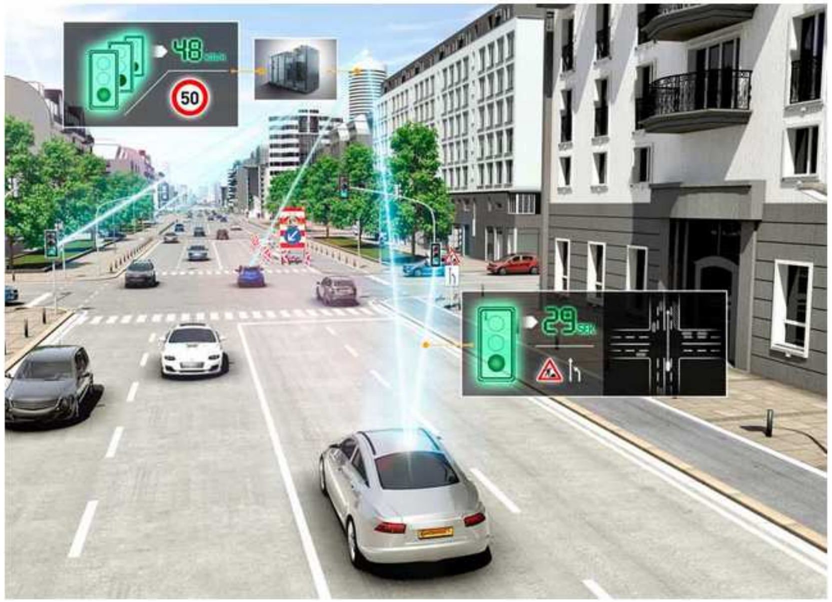
IoT and the Connected Age



Source: www.todaysmotorvehicles.com

Source: www.extremetech.com

Source: www.dreamtimes.com



Source: here.com

IoT and Intelligent Transport

- Many sensors are in the transport infrastructure

- Users (equipped with wireless devices) provide and access to valuable information

Vast amount of information is available

What “**having information”** actually means?

Outline

- Route choice and UE
- Stochastic network and routing
- The value of information
- Conclusion

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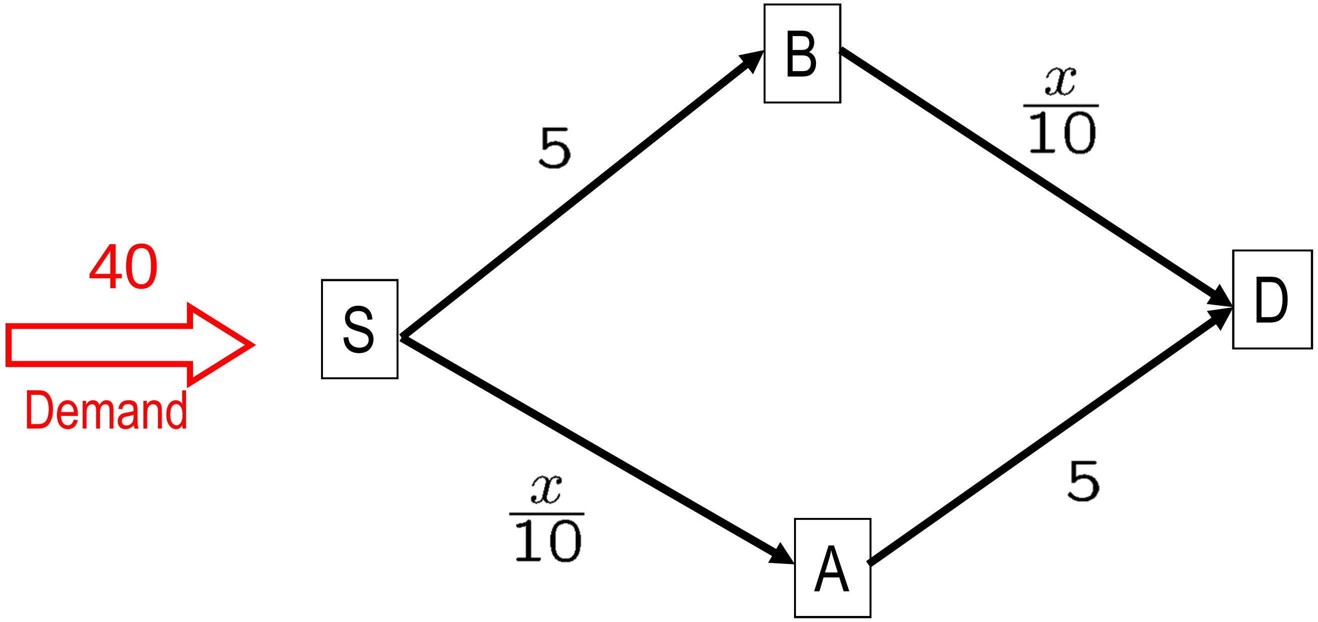
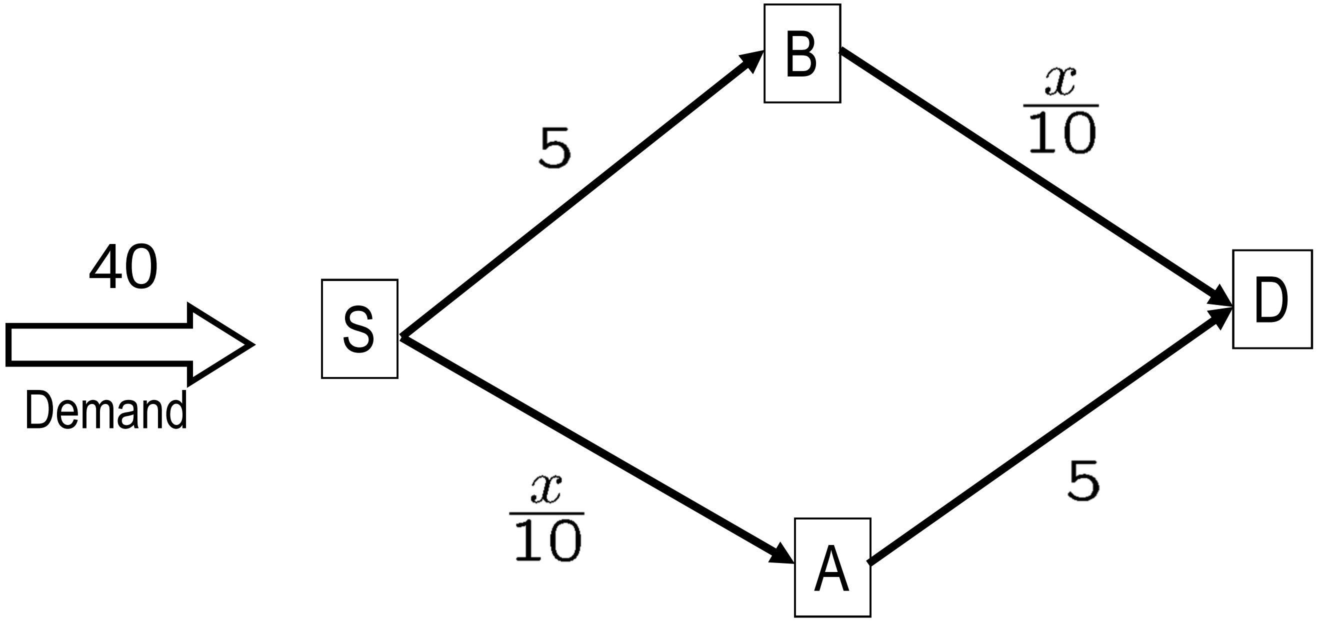
Route choice behaviour



User equilibrium (UE): no user can improve his travel time by *unilaterally* changing route (Wardrop, 1952)

User Equilibrium (UE)

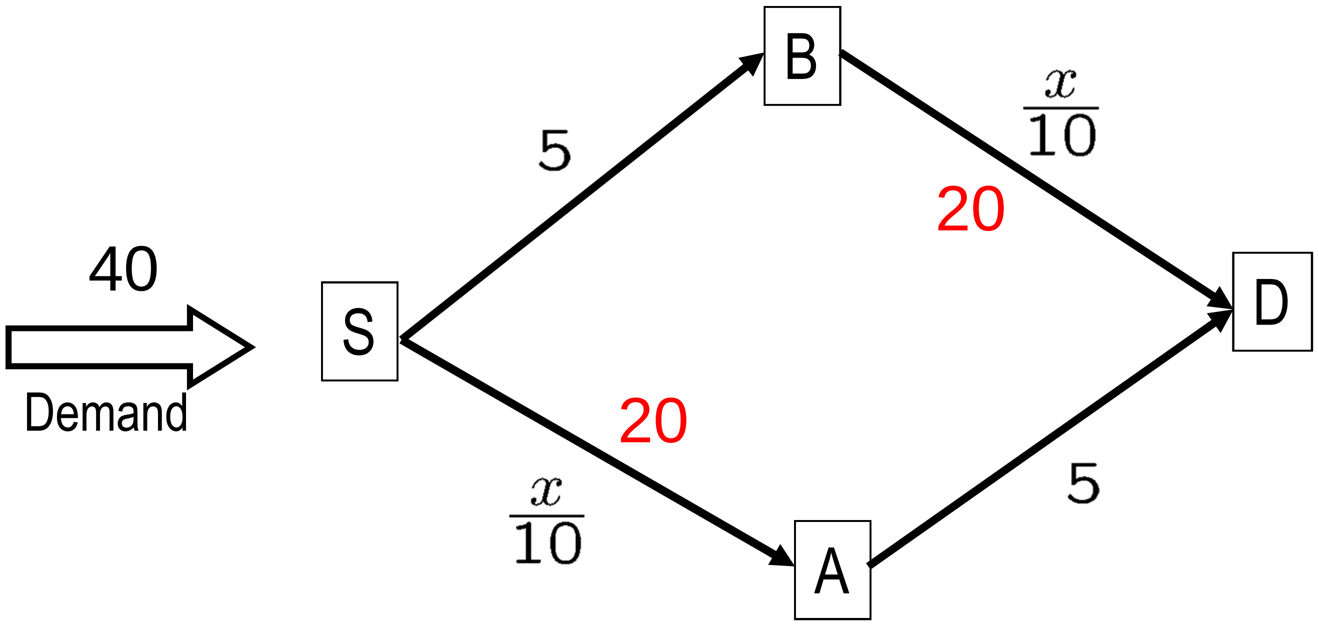


find x_1, x_2 such that:

$$5 + x_1/10 = 5 + x_2/10$$

$$x_1 + x_2 = 40$$

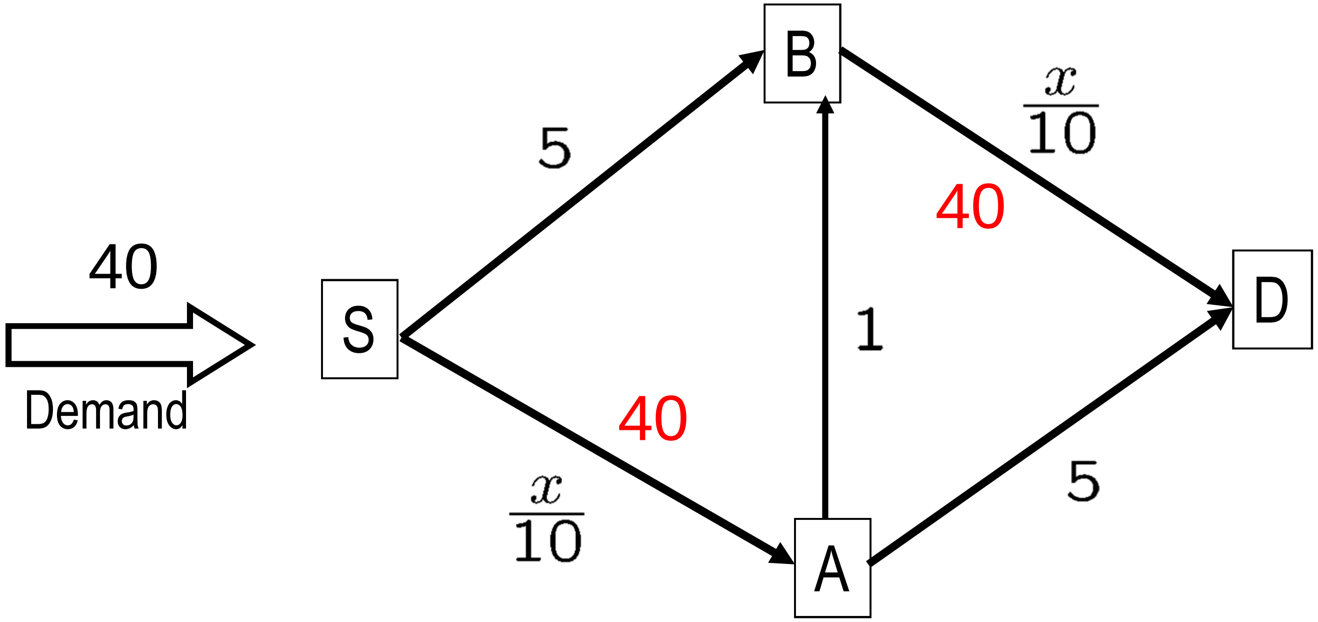
UE solution



Path cost: $5 + 20/10 = 7$

System cost: $2 \times (20 \times 7) = 280$

Braess paradox



Path cost: $2 \times 40/10 + 1 = 9$ vs. 7

System cost: $40 \times 9 = 360$ vs. 280

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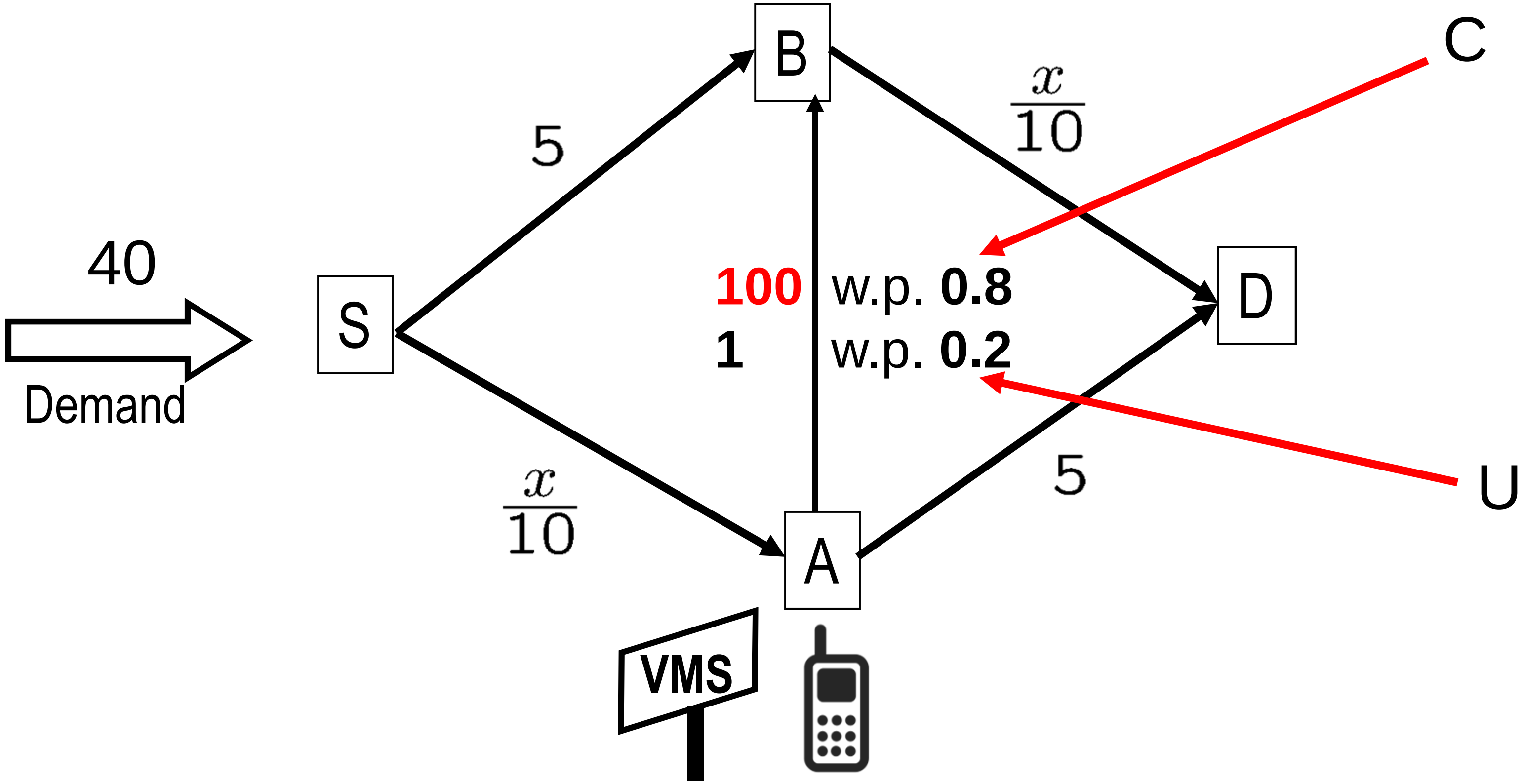
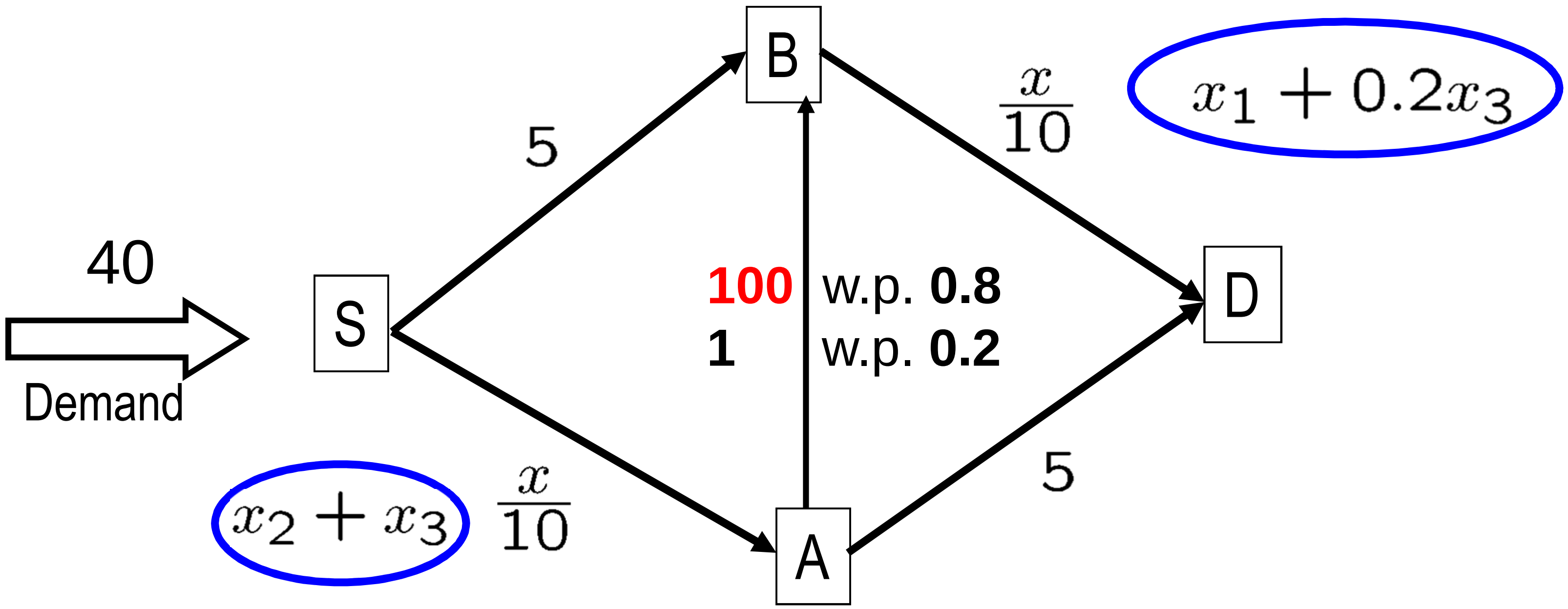
Stochastic network



And real time information is available.

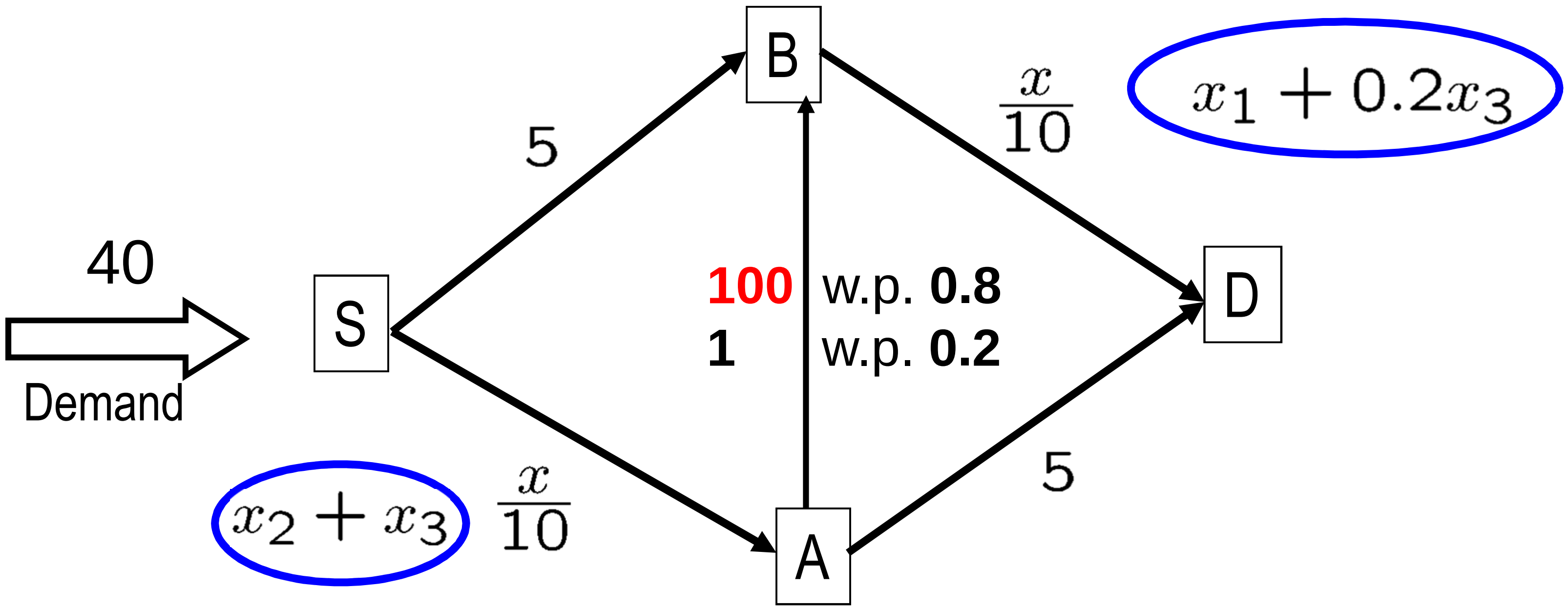
Routing with information



Given the information, possible routing decisions:

$$P_1.\ x_1: \quad S - B - D$$
$$P_2.\ x_2: \quad S - A_{C,U} - D$$
$$P_3.\ x_3: \quad S - A_C - D \text{ or } S - A_U - B - D$$

Cost of routing policies

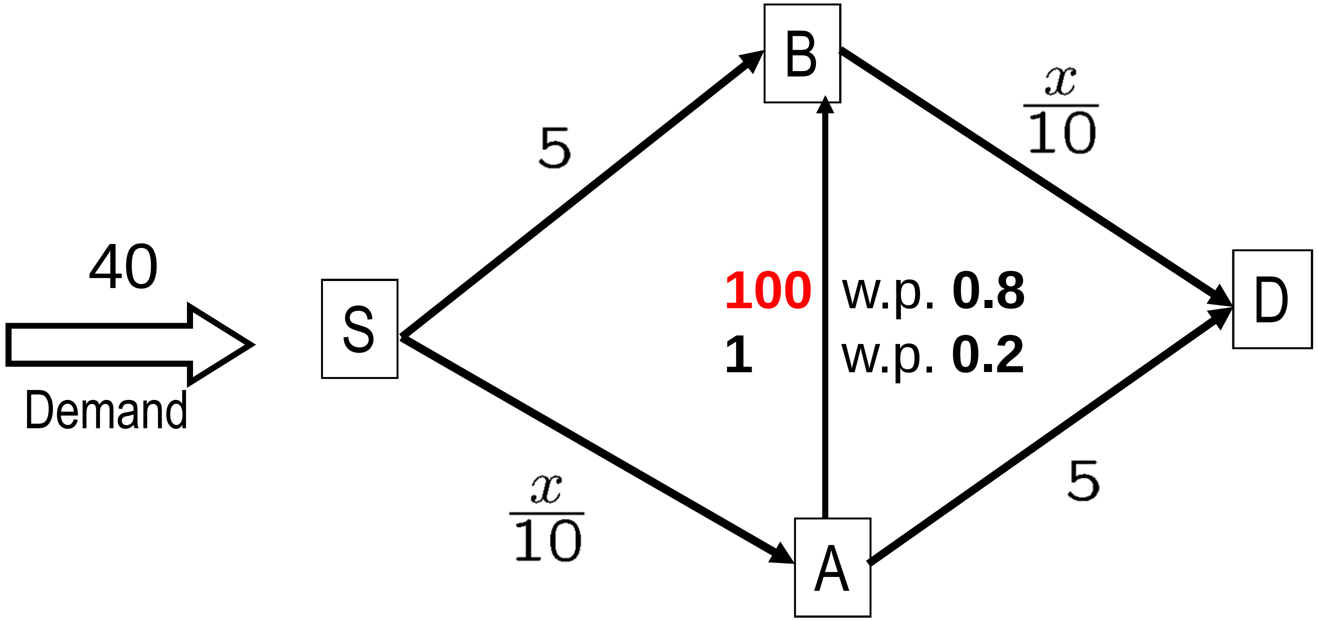


$$C(P_1) = SB + BD = 5 + (x_1 + 0.2x_3)/10$$

$$C(P_2) = SA + AD = (x_2 + x_3)/10 + 5$$

$$C(P_3) = SA + 0.2(AB + BD)_U + 0.8(AD)_C = (0.8x_2 + x_3)/10 + 5$$

The new UE



$$x_1 + x_2 + x_3 = 40$$
$$C(P_1) = C(P_2) = C(P_3)$$

$$x_1 = 17.78, \; x_2 = 0, \; x_3 = 22.22$$

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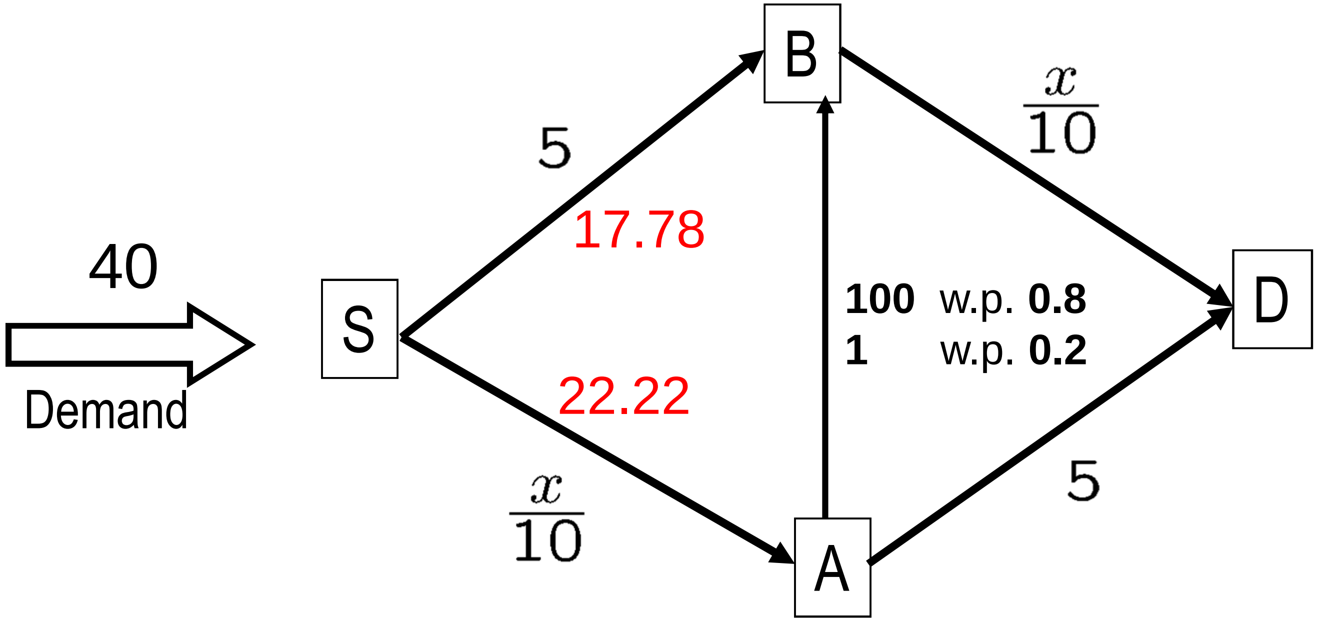
The value of information

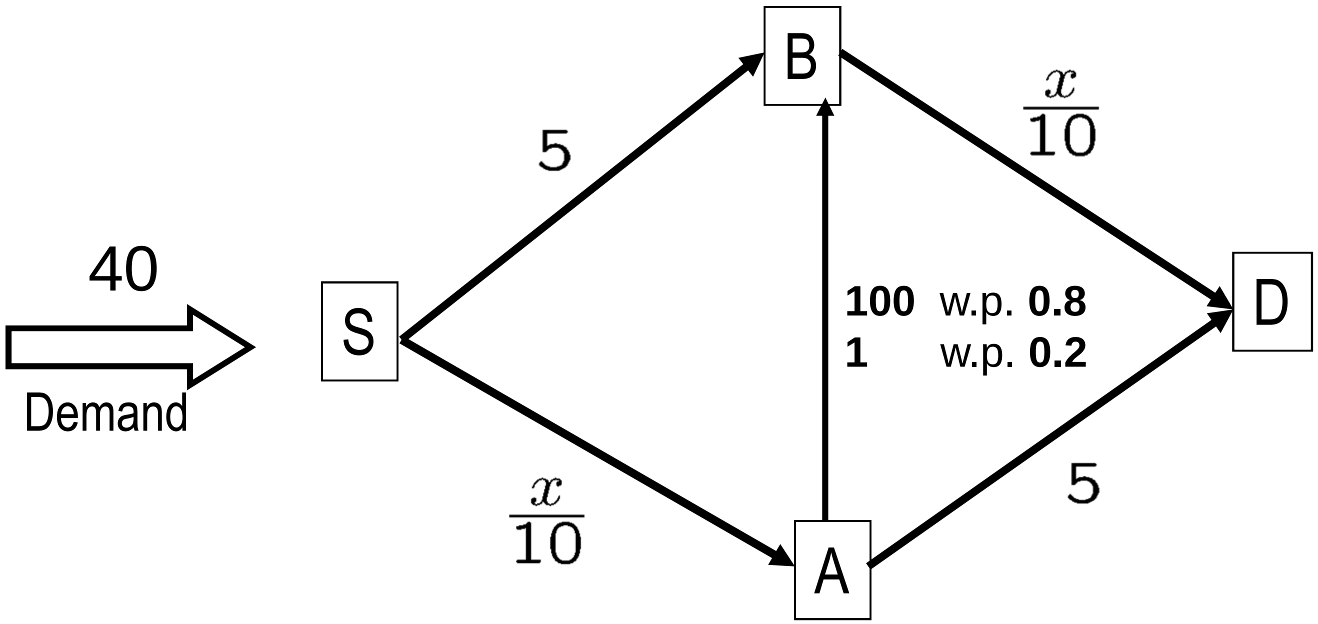


Policy cost: $5 + (17.78 + 0.2 \times 22.22)/10 = 7.22 < 9$

System cost: $40 \times 7.22 = 288.9 < 360$

Information does help to reduce the cost ... (7, 280)

The value cont.



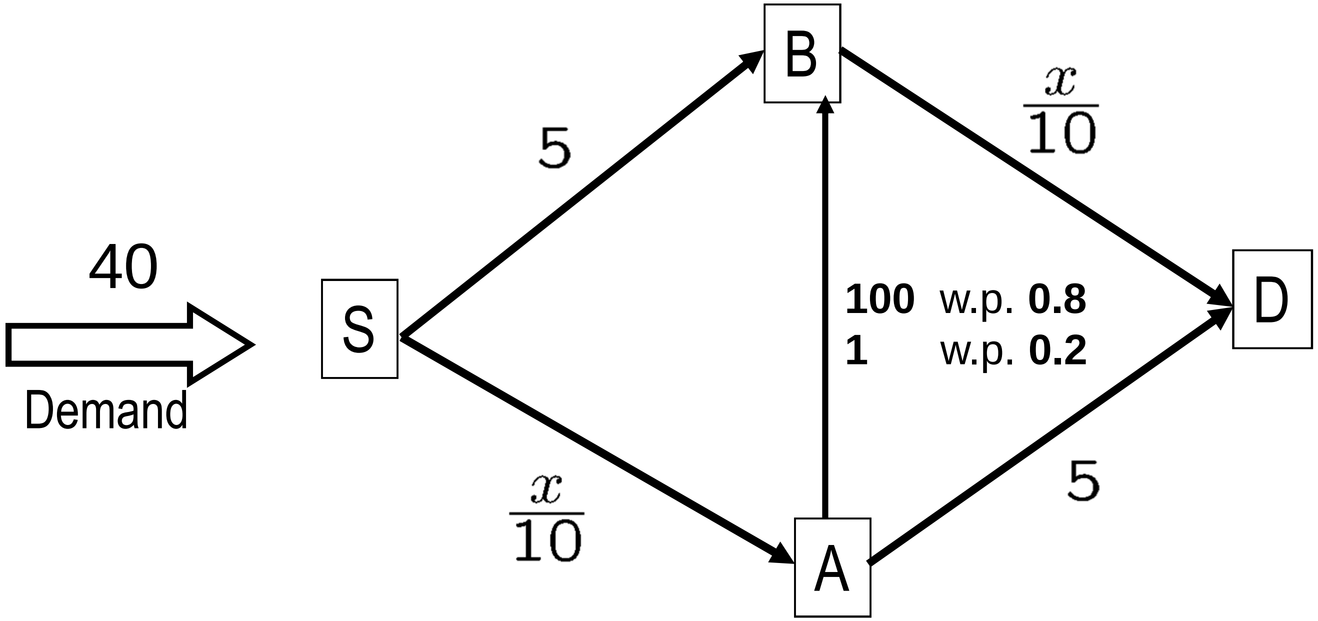
$P_1.\ x_1 = 17.78\ (S - B - D)$

$P_2.\ x_2 = 0:\ (S - A_{C,U} - D)$

NO ONE would ignore information

$P_3.\ x_3 = 22.22:\ (S - A_C - D \text{ or } S - A_U - B - D)$

What if?



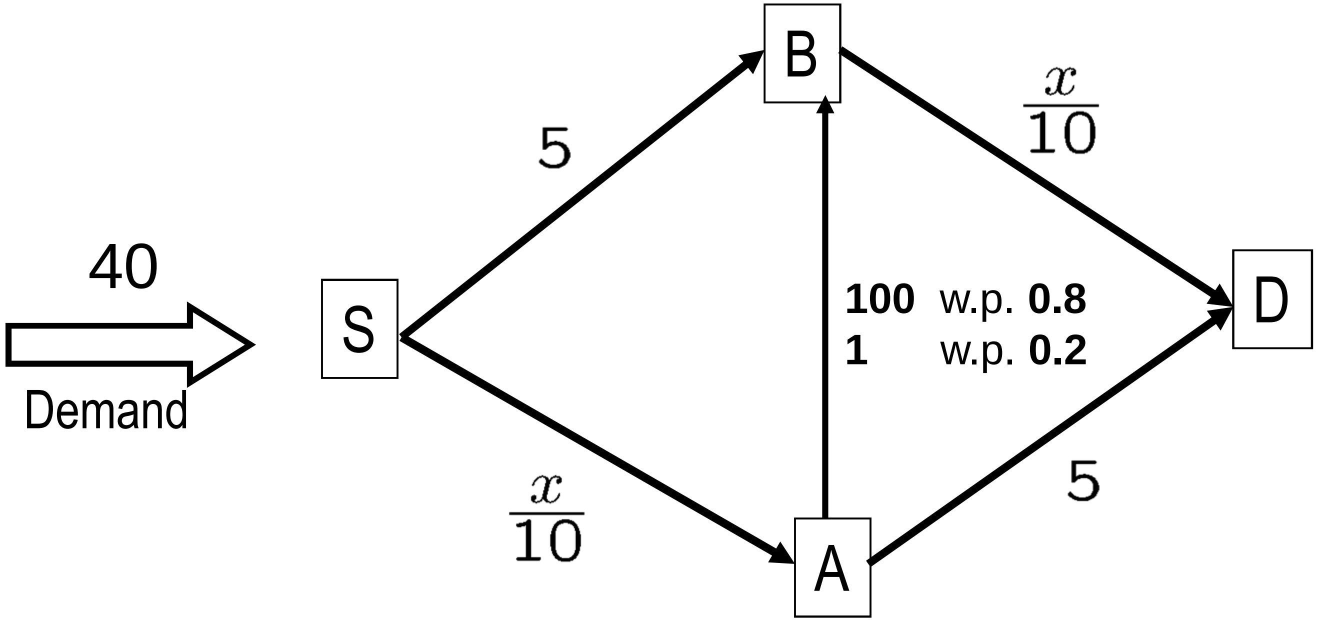
$P_1.\ x_1:\ (S - B - D)$

$P_2.\ x_2:\ (S - A_{C,U} - D)$

$P_3.\ x_3:\ (S - A_C - D$ or $S - A_U - B - D)$

EVERYONE would ignore information

What if? cont.



Ignore info, too risky to take AB

UE: $\{P_1, P_2\}$ with $x_1 = x_2 = 20$

$C(P_1) = C(P_2) = 20/10 + 5 = 7$

Naïve no info

UE: $\{P_4\}$ with $x_1 = x_2 = 40$

$C(P_4) = 2 \times 40/10 + 1 = 9$

$$P_4 : \ (S - A_{C,U} - B - D)$$

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Conclusion

- Information does help improve the user experience and network performance

- But it can also cause the performance degradation

- There exits an information paradox

- More research is required to fully understand the impact of information use

Acknowledgments

- This work is supported by the ARC Future Fellowship grant (FT120100723)

- The example in the talk was inspired by the paper of Unnikrishnan and Waller (New Spat Econ(2009) 9:575–593)

- Slides are prepared in discussions and with the help of my PhD student N.H. Hoang

THANK YOU

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