It pays to do the right thing:
Incentive mechanisms for decongesting roads

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N.S. Rama and many other Infoscions
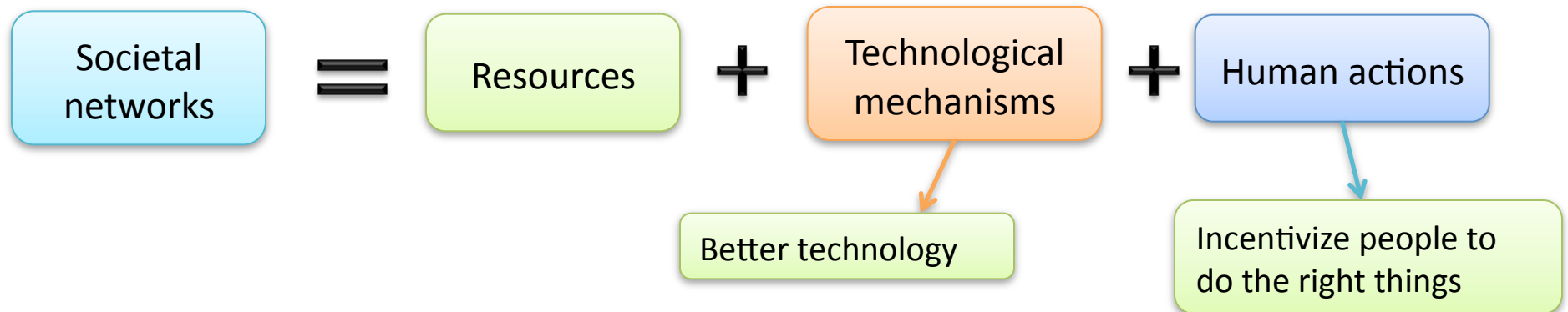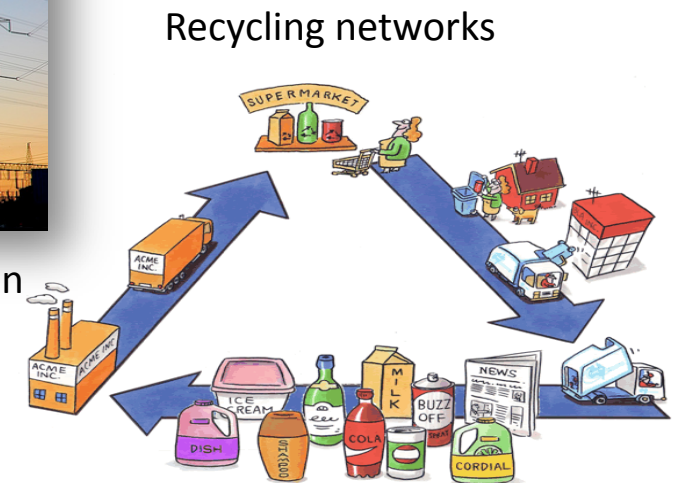
Societal networks

- Societal networks: Networks concerned with societal processes
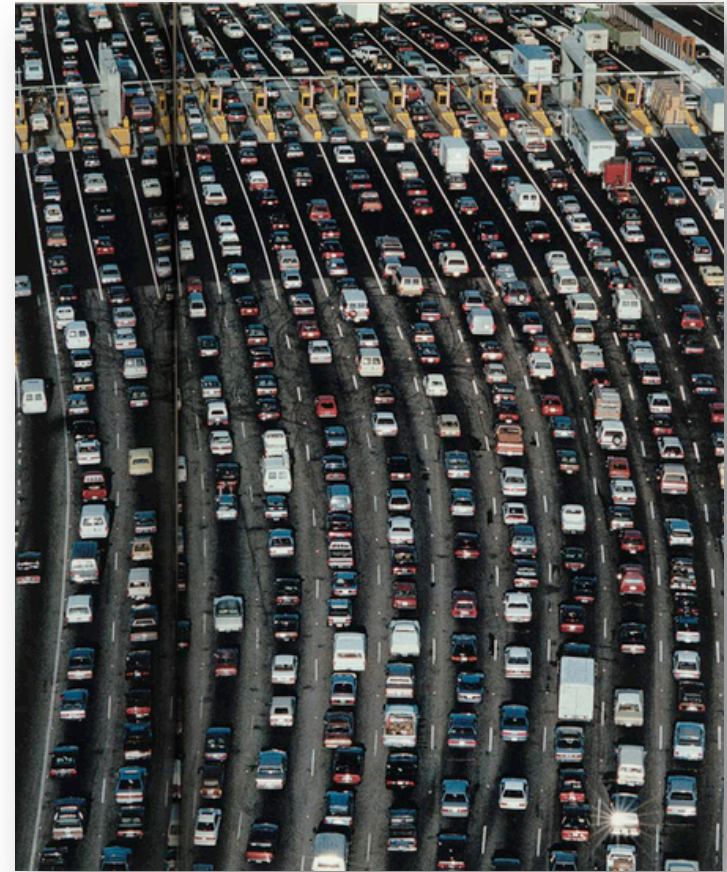

Transportation networks – congestion

Electricity networks – generation and consumption

Recycling networks

Societal networks	=	Resources	+	Technological mechanisms	+	Human actions

Better technology

Incentivize people to do the right things

Cost of congestion

- Fuel and time costs in 2005, US-wide

    A. $ 8 million

    B. $ 80 million

    C. $ 8 billion

    D. $ 80 billion

- US auto bailout: $ 25 billion
- Stimulus package for Wall Street: $ 700 billion

Fuel cost

- Fuel wasted in urban U.S. in 2005

    A. 3 million gallons

    B. 30 million gallons

    C. 3 billion gallons

    D. 30 billion gallons

- Equal to fuel consumed in all of the U.S. in 6 days !
    - 2006 data

Congestion pricing

- Current methods: Charge drivers who enter "congested zone"
  - E.g. London, Singapore, Stockholm
  - Effective, but viewed as "yet another tax"

- Our proposal: Charge congestors, pay decongestors
  - Put "intelligence" in vehicles, not on road
  - Deploy incrementally, no need for *every one* to start on day one

Auxiliary Thesis

- Small good deeds don't carry adequate rewards, so they aren't performed
  - A system, which pools individual rewards, but pays out a few large sums through raffles may carry adequate incentives

- In games with low stakes, players are more risk seeking

- Two envelope game:
  - Envelope 1: $10
  - Envelope 2: $110 with 10% chance, $0 else (Ave = $11)
  - Q: Which will you choose?

- Version 2:
  - Envelope 1: $1
  - Envelope 2: $11 with 10% chance, $0 else

- Theorem: If you choose Envelope 2 in Version 1, you will also choose it in Version 2

More precisely

- Let *U(.)* be a concave utility function with *U(0)=0*, and assume one of the following two conditions holds:

  1. $-xU''(x)/U'(x) \geq 1$ (This is the well known Relative Risk Aversion function)
  2. $xU'(x)/U(x)$ is a monotonic decreasing function.

- If $X \geq 0$ is a random variable representing payoff, then for $0 < \delta < 1$, $E[U(X)] - U(\delta E(X)) \geq 0$ for sufficiently small $E(X)$.

Experimenting with Societal Networks

- Transportation networks
  - The INSTANT project
  - Congestion at Stanford, etc

- Recycling: Freshman seminar in Spr 2010

The INSTANT project

- The INSTANT (Infosys-Stanford Traffic) project is a pilot study of using an incentive mechanism to decongest road traffic
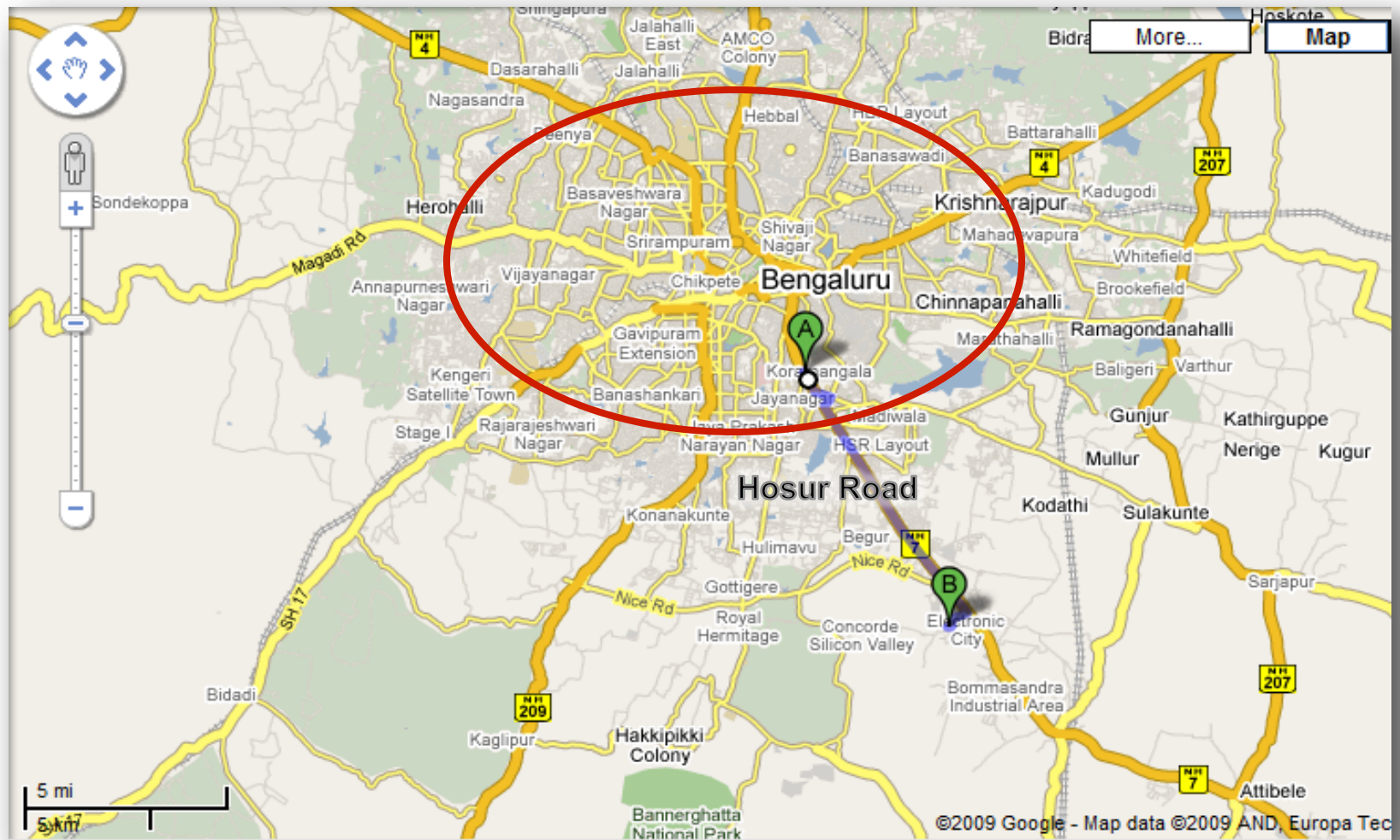
Bus data

- 240 buses, 120 starting points, 4 major routes

- Data from January 2005 to June 2008

  - Pick up, drop off times; bus occupancies

Bus #	Pick-up Time	Drop Time	Pick-up Point	Cap	A	B	C
54	700	732	JAYA NAGAR 4TH BLOCK /18TH MAIN	49	61	12	
56	650	738	NANDIGARDEN / R.V.DENTAL COLLEGE	49	45		4
57	700	752	JAMBUSAVARIDINNE/R.V.DENTAL	49	38		11
60	700	745	GOTTEGERI / B.G.PARKING LOT	49	28		21

A - Occupancy
B - Standing
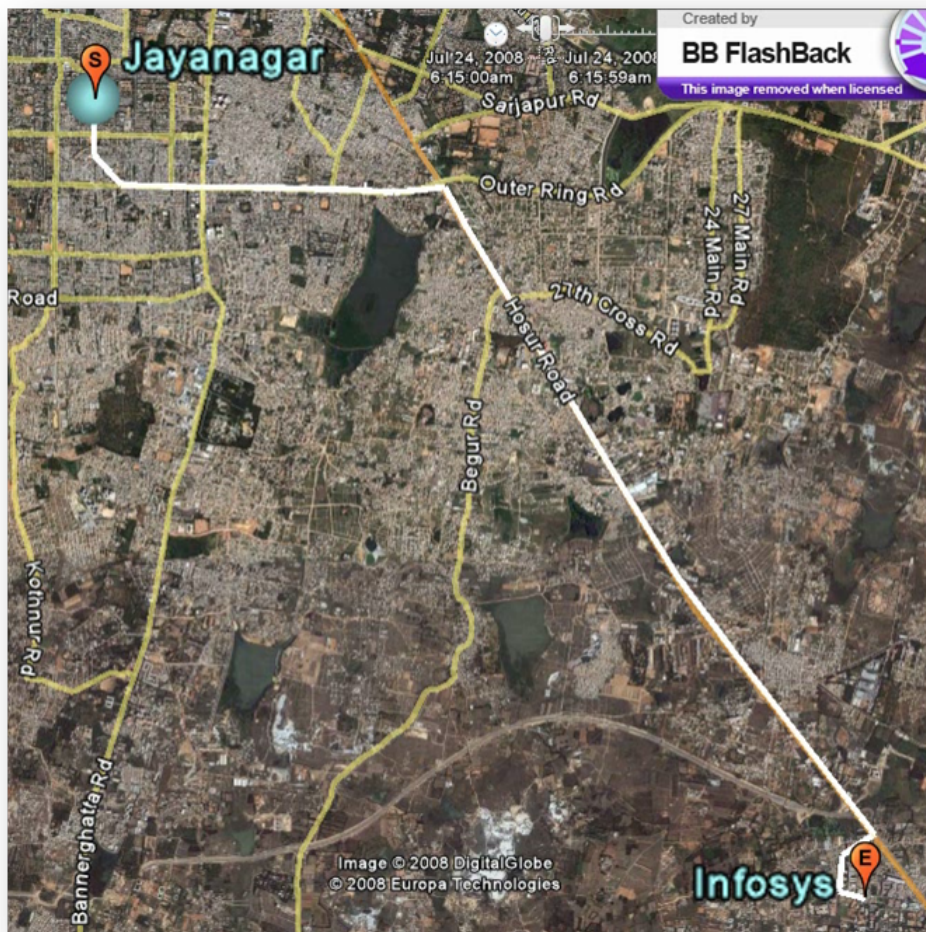C - Empty Seats
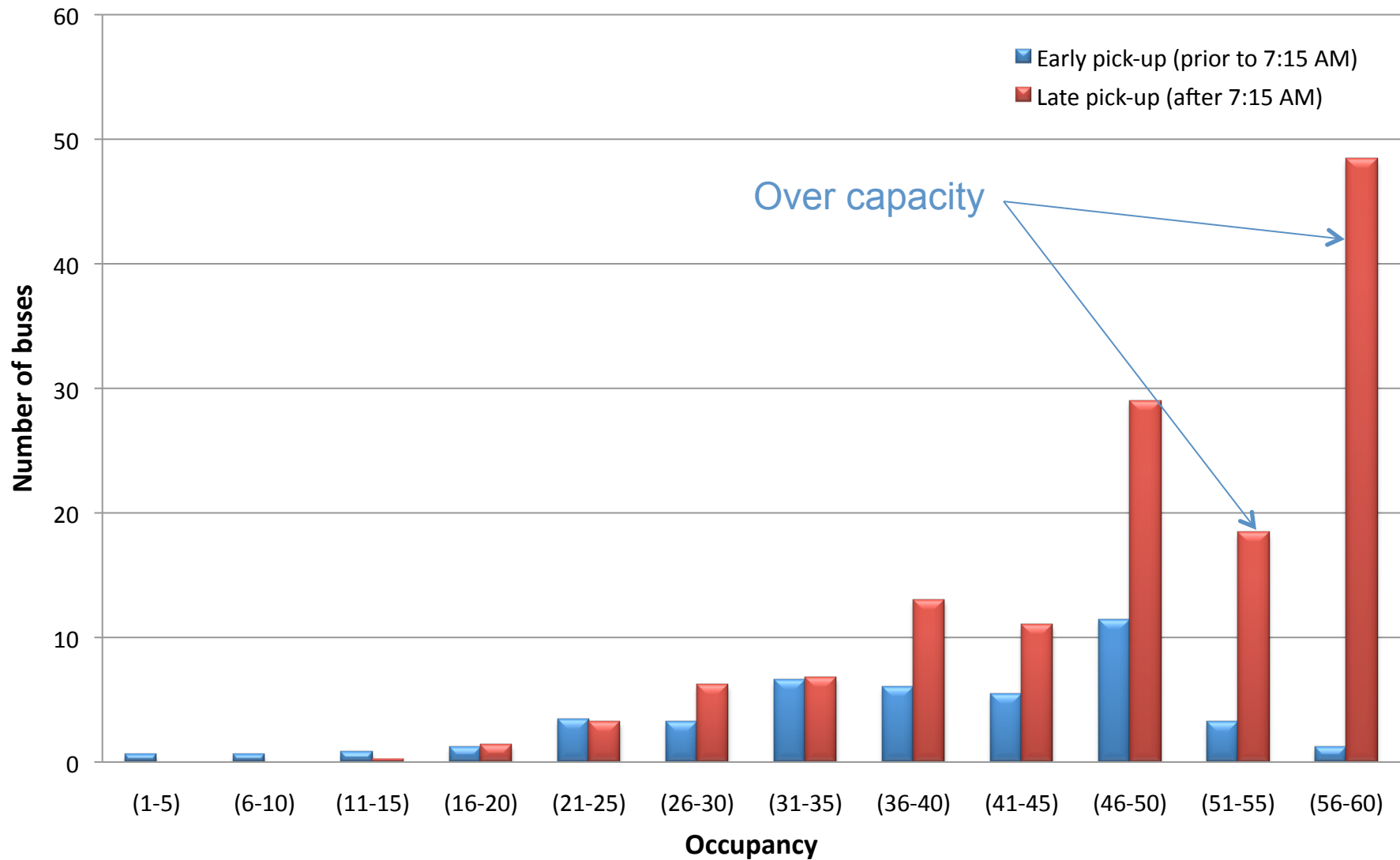
Journey times from Jayanagar
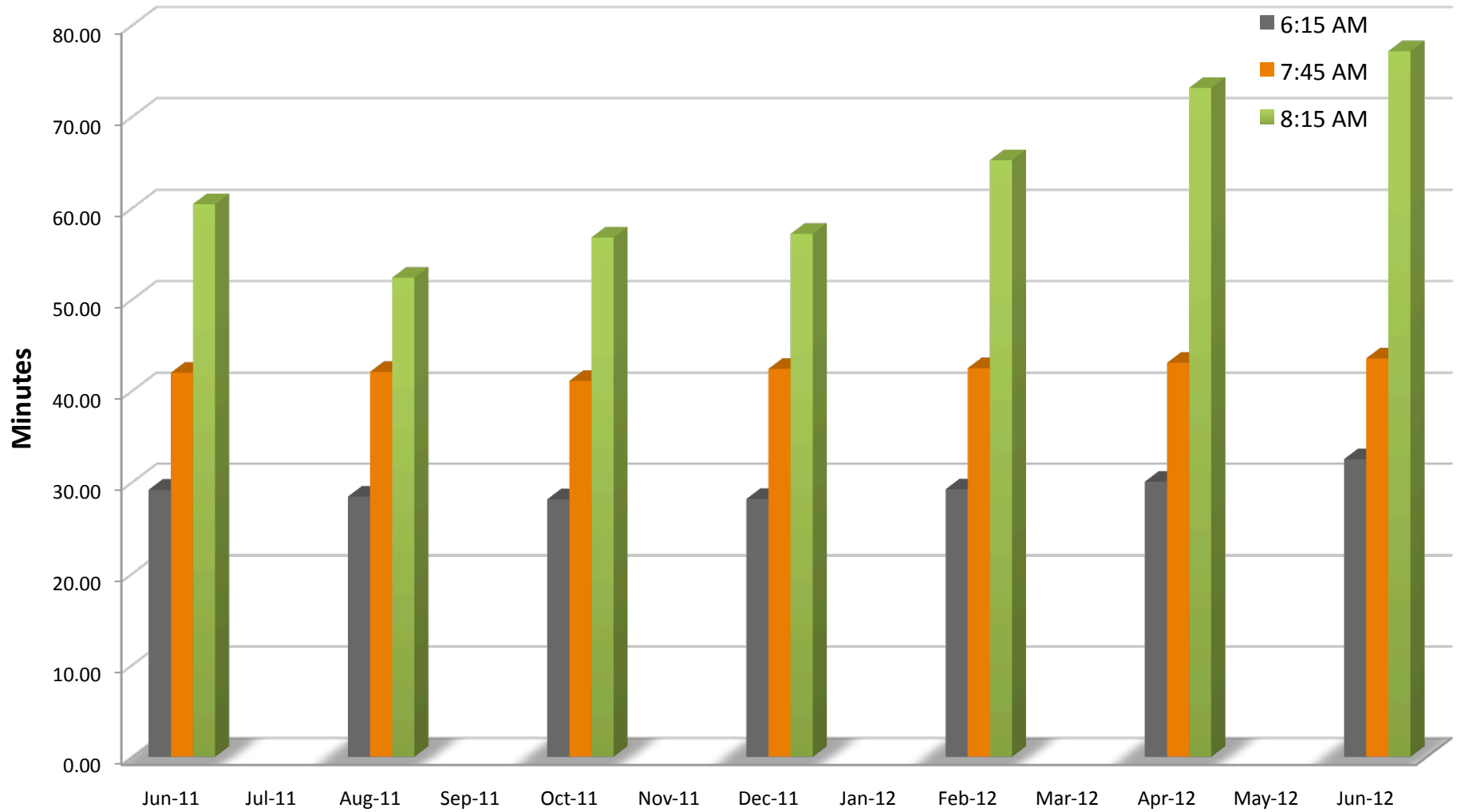
GPS Video
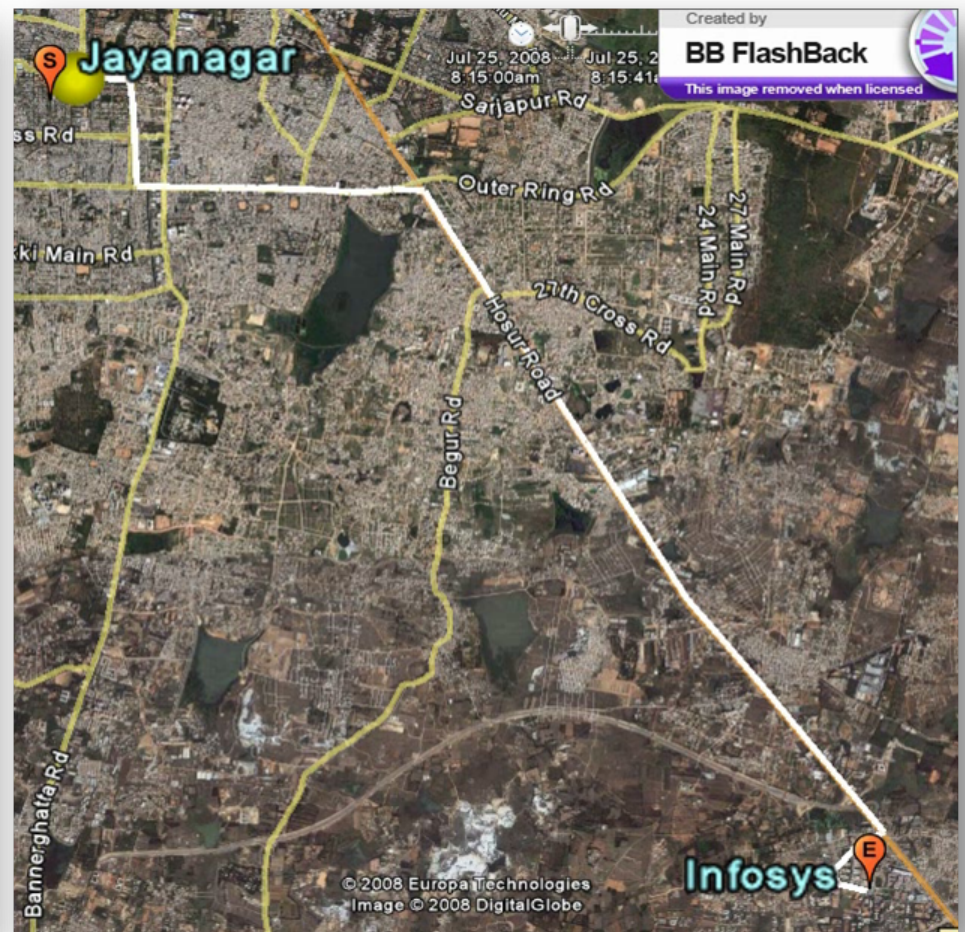
- Warning: Portions of this material may be disturbing for some viewers. Discretion is advised.

Morning GPS trace:
Jayanagar to Infy

6:15 AM

8:15 AM

Morning GPS trace:
Jayanagar to Infy

Commute time: 29 mins.
6:15 AM
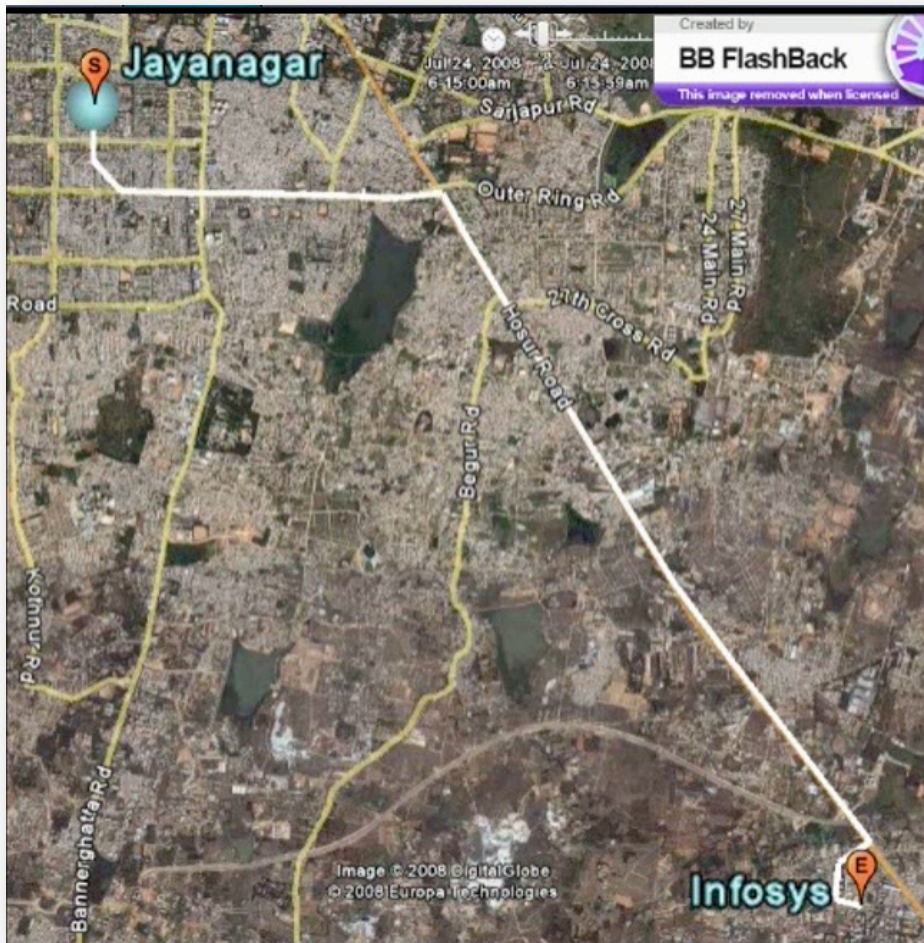
Commute time: 82 mins.
8:15 AM

The incentive mechanism
At a Glance

Commuter's working day begins

↓

Arrival (swipe-in) time

Arrival before 8.00 AM → Earn 1.5 credits

Arrival between 8.00 – 8.30 AM → Earn 1 credit

Arrival after 8.30 AM → No credit

Earn 1.5 credits → Incentive mechanism ← Earn 1 credit

Incentive mechanism → Rewards given weekly

An illustration

2 x 12,000 (20)

4 x 6,000 (12)

14 x 2,000 (7)
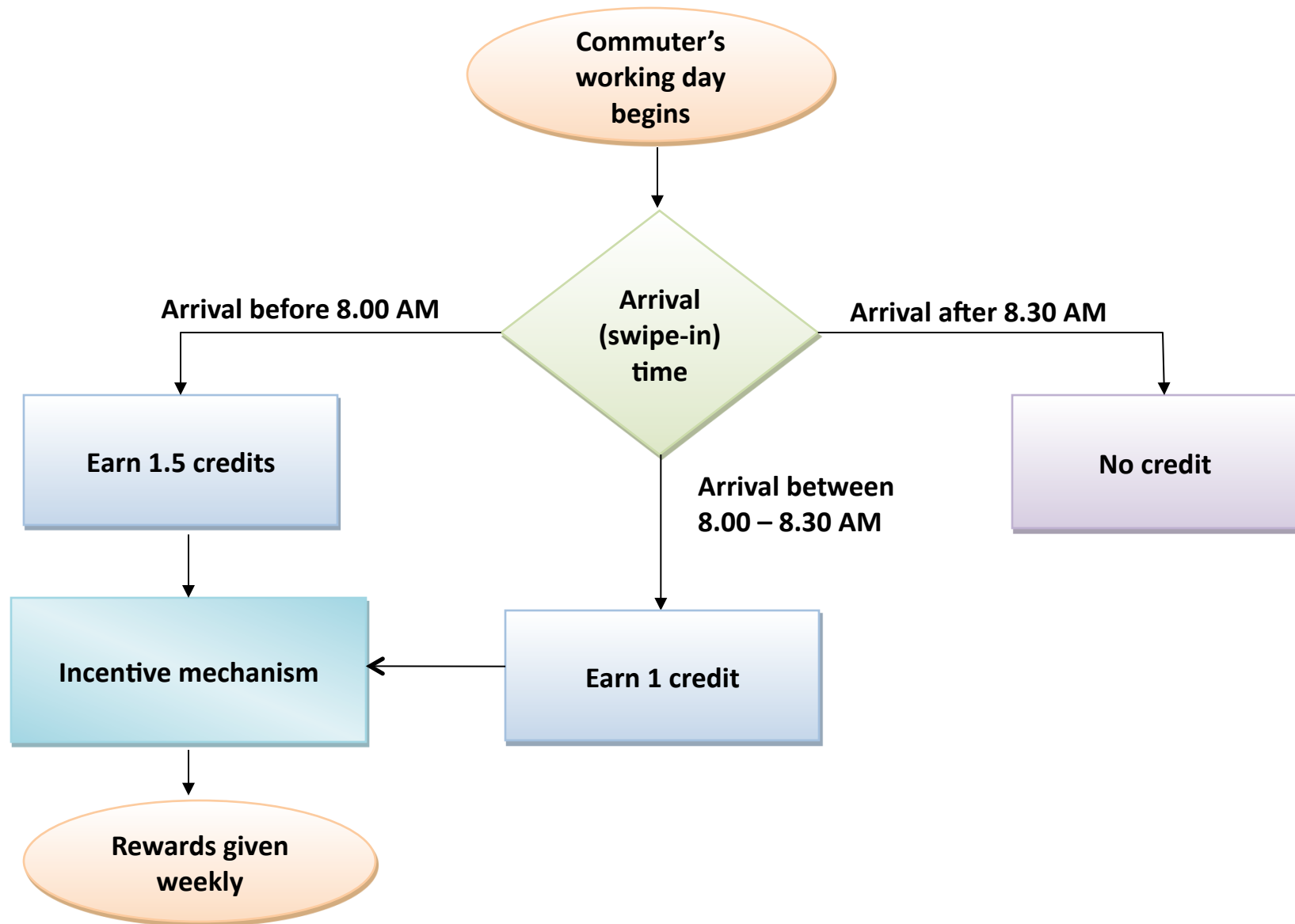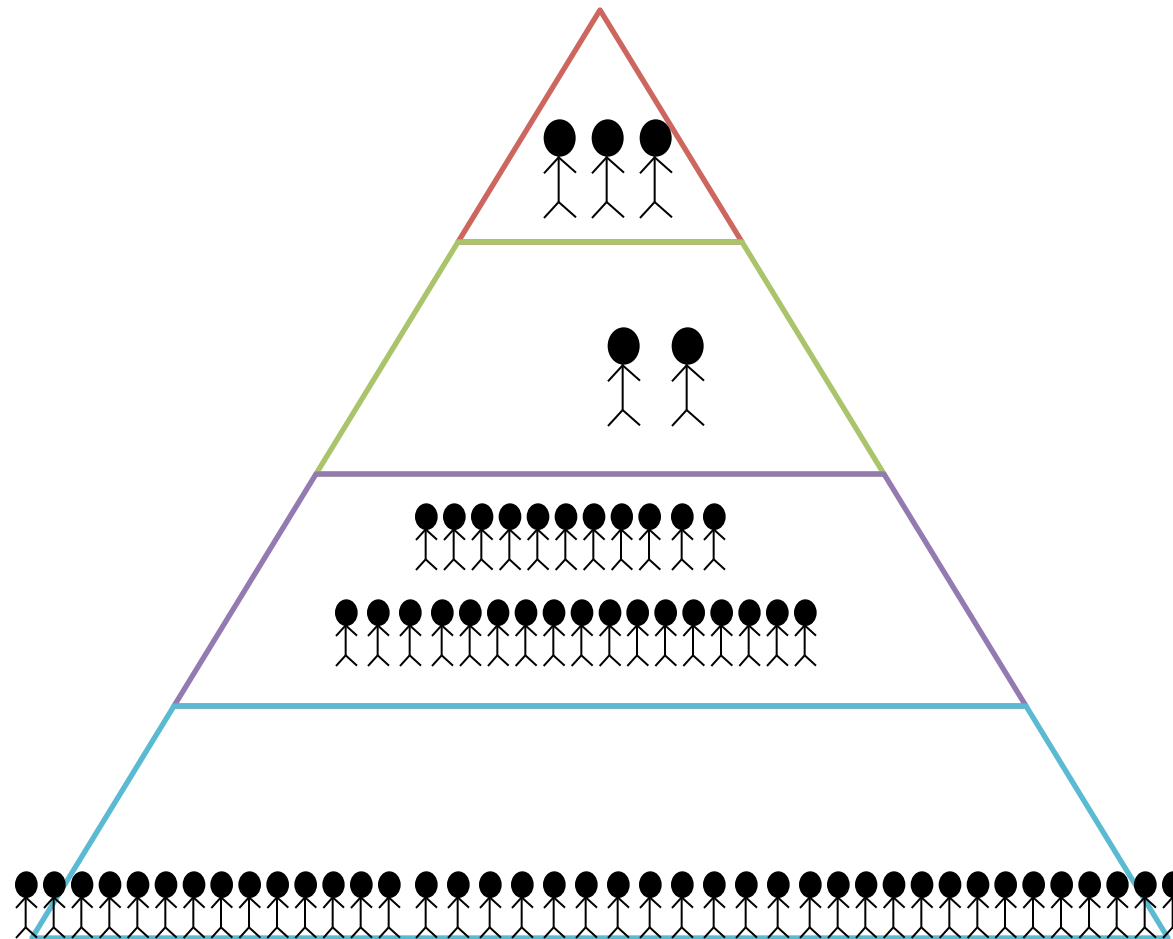
58 x 500 (3)

Results

Commuter arrivals
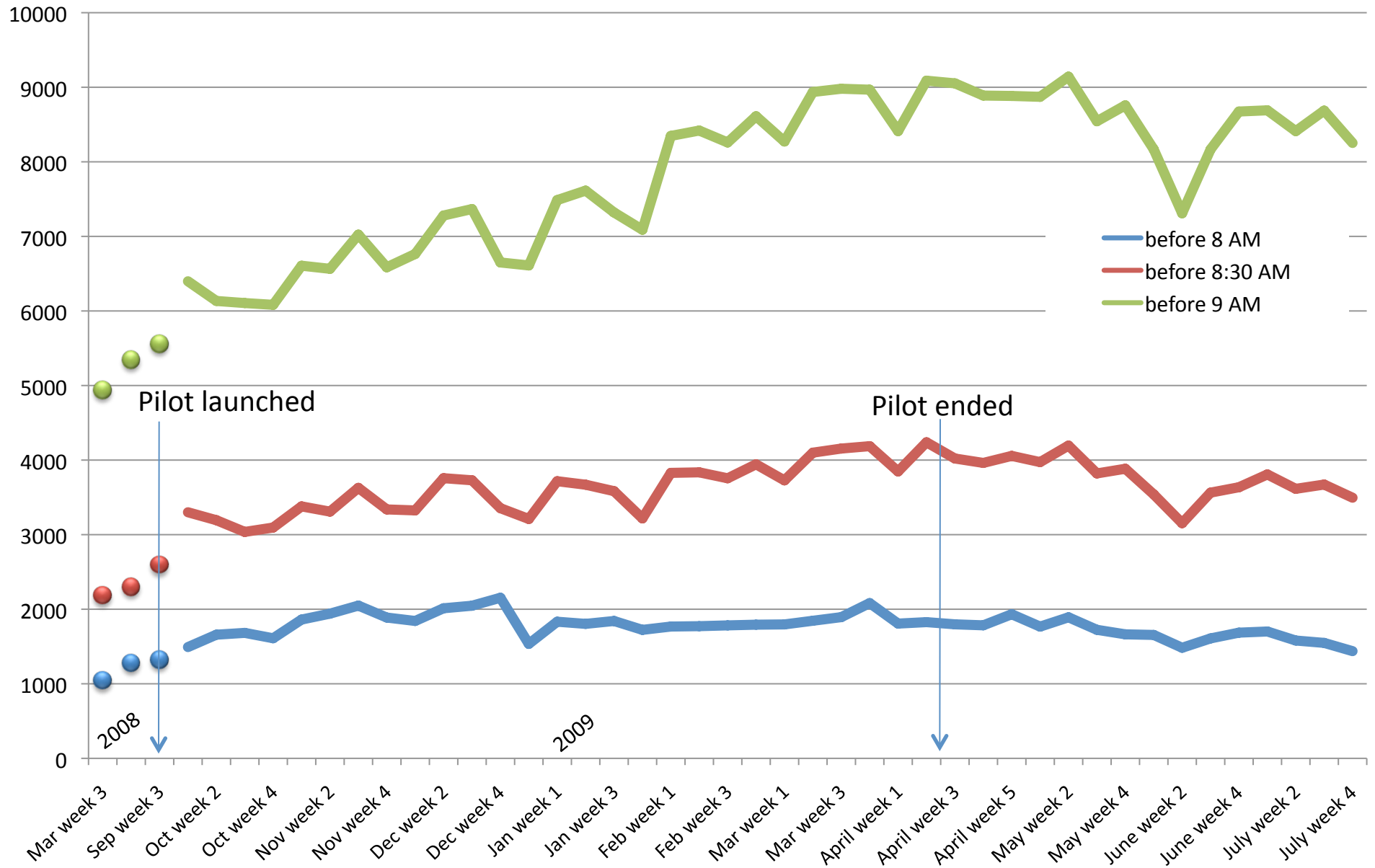
Average morning bus commute time (and total person-hrs saved)

Summary of INSTANT

- Reduction in commute times: at least 80 mins each day

- More comfortable rides

- Savings in fuel cost: Rs. 15,000 per day

- Reduction in bus fleet size: 8 buses

- Infosys will launch INSTANT at all 8 of their India offices

At Stanford

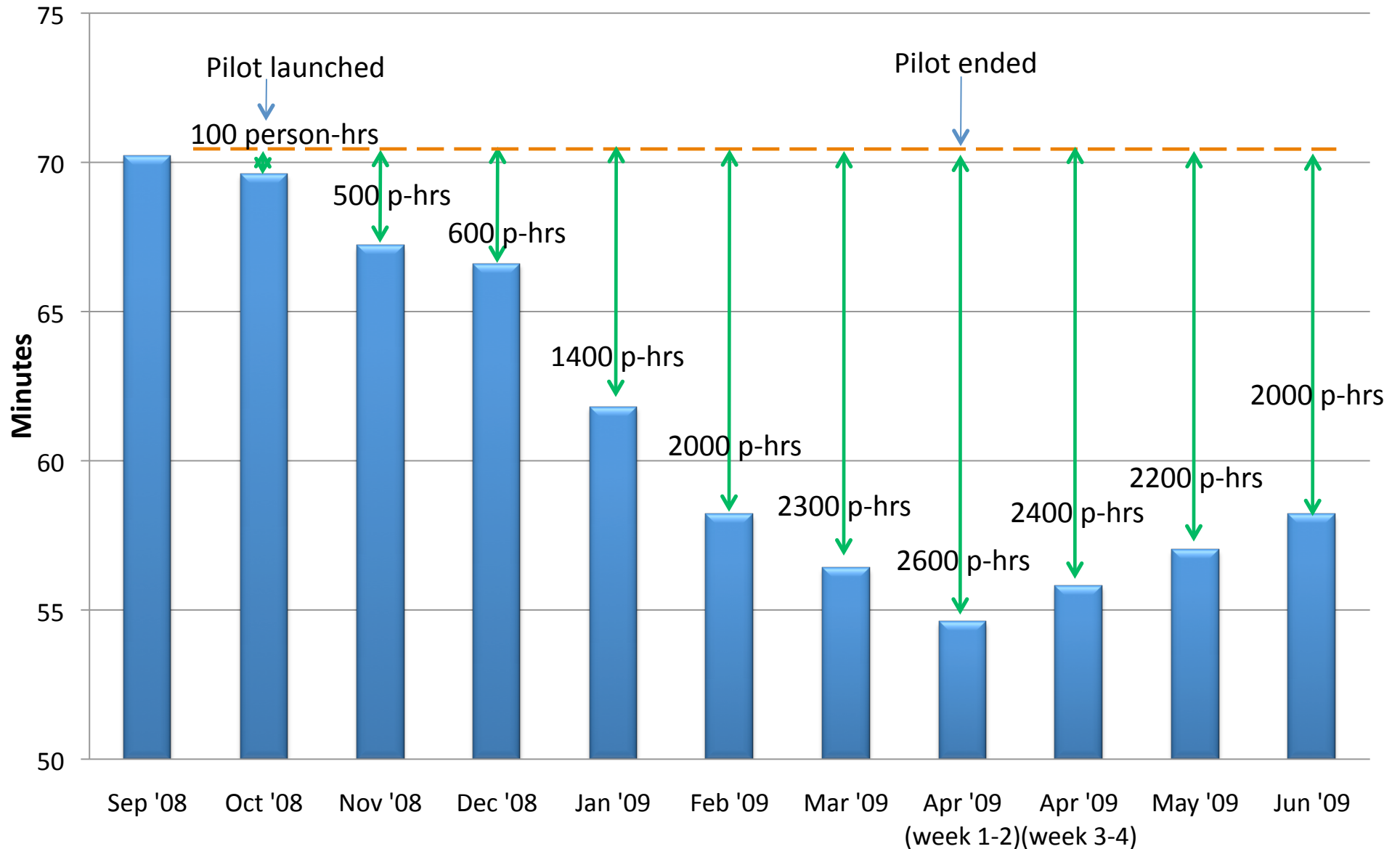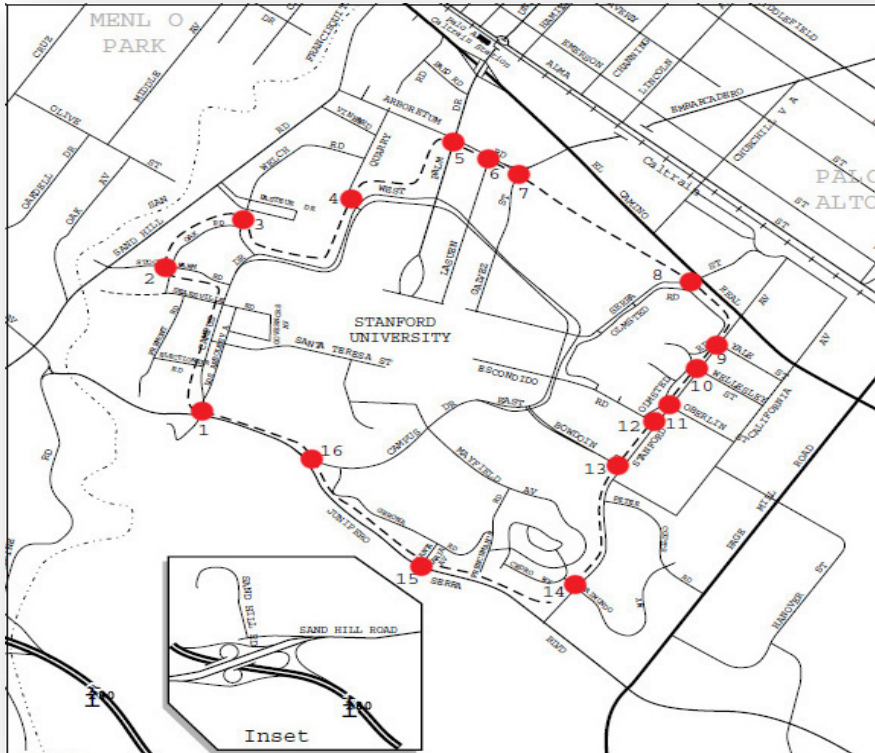- Parking at Stanford: Reduce peak hour trips

Stanford congestion

- Agreement with Santa Clara County in 2001
  - Morning inbound limit = 3,319 vehicles, + 1% tolerance
  - Evening outbound limit = 3,446 vehicles, + 1% tolerance

Date: 04/09/2008; Time period from 8:00:00 AM to 9:00:00 AM

Site In	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Match IN	Total IN
1		8	88	2	4		3	1					1			1	108	583
2	16		32	2	2		1	2	1				2				58	440
3	21	2		1			2	5					1				32	217
4	4	1	7		3		2						3				20	167
5	20	5	9	19		1	5	5	1				6			2	73	498
6			1													1	2	25
7	6	2	6	9	1	2		6	1				7			5	45	546
8	1		3	2			4		5			1	3			5	24	305
9								1			1						2	29
10												1	1			1	3	7
11								3	2		41	3					49	83
12	1						4				1	1					7	25
13	1		2	15	4		7	2	2			1		1		7	42	410
14							1					2					3	52
15																	0	14
16	2		1	2	5		5	10					6				31	301
Match OUT	72	18	148	53	19	3	30	36	13	2	2	44	36	1	0	22	499	3702
Total OUT	145	63	297	151	101	4	155	172	57	21	25	72	137	41	9	104	1554	13.5%

Our proposal

- In collaboration with P&TS
  - RFID parking stickers
  - Incentive mechanism allows commuters to earn back part of their parking fees
  - We'll have both deterministic and random payoffs

Formal structures

- Under formation: Institute/center on Societal Networks
- Scientific Board
  - Kenneth Arrow, Stanford
    - Joan Kenney Professor of Economics and Professor of Operations Research
    - Convening Lead Author: Intergovernmental Panel on Climate Change
  - Frank Kelly, Cambridge
    - Professor of the Mathematics of Systems, Master of Christ's College
    - Chief Scientific Adviser to the UK Department for Transportation, 2003--2006
  - Pravin Varaiya, Berkeley
    - Nortel Networks Distinguished Professor, EECS
    - Director of California PATH Program, 1994--1997
  - Hal Varian, Berkeley/Google
    - Professor: School of Information, Haas School of Business, Dept of Economics
    - Chief Economist, Google