

Beyond the Physics of Queueing for *ESD.86*

Richard C. Larson

Massachusetts Institute of Technology

Cambridge, Massachusetts

March 19, 2007



Queueing Models

- ◆ A queue is a waiting line
- ◆ Uncertainties cause delays
- ◆ Usually there is uncertainty in:
 - The arrival times of customers
 - The service requirements of customers
 - The urgency with which a customer must be served

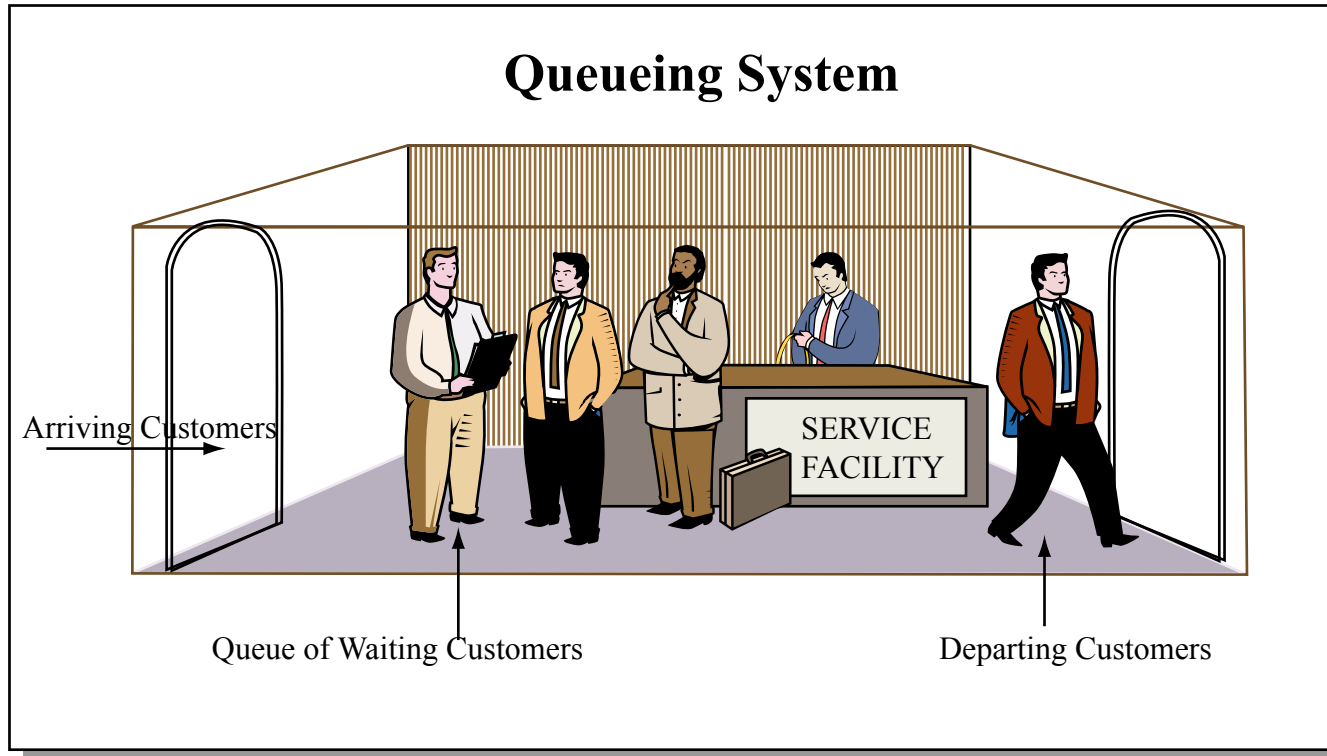


Figure by MIT OCW.

Some Familiar Queues:

- ◆ Fast food restaurants
- ◆ Toll booths
- ◆ Retail shopping
- ◆ Airports
- ◆ Automatic Teller Machines
- ◆ Waiting lists for college acceptance
- ◆ On hold to an “800 number”



Photo courtesy of 'hugovk' - <http://www.flickr.com/people/hugovk/>
Source: http://static.flickr.com/22/26138106_1c78dbd2c8.jpg

There are even police queues

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Logo for 911 Emergency Communications Department

URL: <http://www.ci.cambridge.ma.us/~ECD/>

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Cover of book *The Queue* by Vladimir Sorokin.

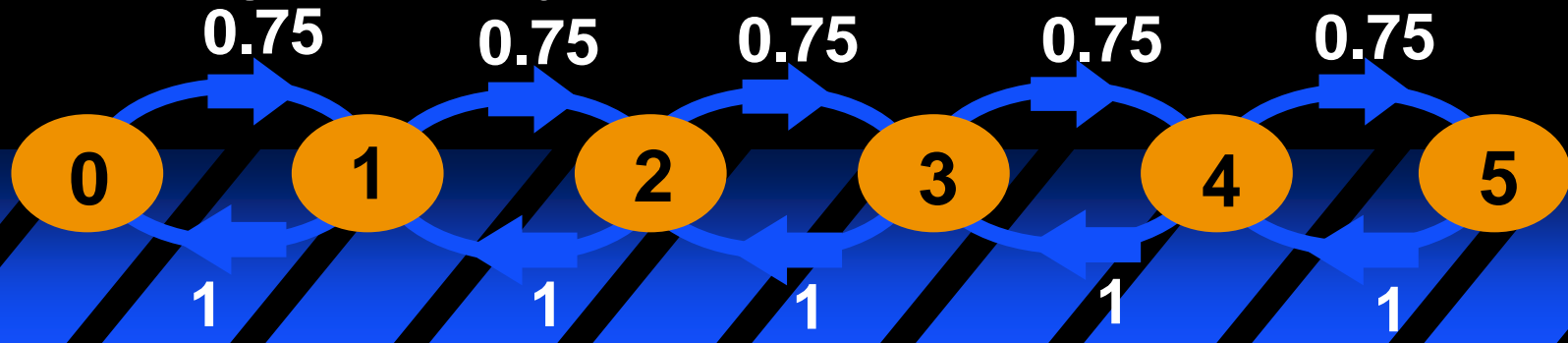
Text removed due to copyright restrictions.
See Melendez, Michele. "Where Do You Stand on Waiting in Line?"
Newhouse News Service, 2005.
<http://newhouse.live.advance.net/archive/melendez112905.html>.
Accessed 6/20/07.

The Birth of Queueing Physics

- ◆ 1915
- ◆ Copenhagen, Denmark
- ◆ A. K. Erlang, Danish Telephone Engineer
- ◆ “Erlang’s formulas” have stood the test of time.

Take-aways from Queue Physics

- ◆ Uncertainty causes delays
- ◆ Can model queueing systems as in physics
- ◆ Explosive nature of queueing as customer arrival rates increase
- ◆ Need to schedule idleness
- ◆ Little's Law: Buy one, get 3 free!
- ◆ Queue discipline may not affect average delay
- ◆ Management objectives must admit some failure!



Year: 1955 Birth of Multi-attributed Queueing

- ◆ New York City
- ◆ Consultant Friend of Russ Ackoff
- ◆ High rise buildings and elevators
- ◆ Queueing delay complaints solved by mirrors!
- ◆ Physics of the queues unchanged!
- ◆ And by coincidence:
 - Anaheim, Cal.: Disneyland Opens.

Factoid:

A large fraction of the founding members of ORSA & TIMS were social scientists, people who would have been interested in the aspects of queues BEYOND PHYSICS.

Queues in the News

- ◆ 4/2/98: “Socialism and its long lines are alive and well at Disneyland”
Peter Passel
NY Times, p. D2

“Patients’ Lives on the Line In Battle Over
Transplants,” Sheryl Gay Stolberg,
NY Times 3/25/98

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How Many of You Know the Queue Discipline for Getting a Dial Tone?

- ◆ Two priority queue
- ◆ You enter as priority 2, LCFS
- ◆ If you are still without dial tone after 15 seconds you shift to Priority 1 FCFS.
- ◆ No priority 2 customers are served when the priority 1 queue is nonempty
- ◆ Why does this make sense?

In competitive service industries,
customers will brand switch as a result of
just one bad service encounter.



Multi-Attributes

- ◆ Delay (FIFO, LIFO, SIRO)
 - ◆ Queueing environment
 - ◆ Information regarding delay
 - ◆ Social justice
- 

Queue Delay: Nonlinearities Often Important

- ◆ Emergencies:
 - Heart attacks
 - Structural fires
 - Broken water mains
- ◆ Individual who misses an airplane because of delay in traffic
- ◆ Customer attitudes
- ◆ Suggests limits for $L = \lambda W$

Close to home:

- ◆ Another nonlinearity: your submitted journal paper is delayed in queue beyond a decision about promotion or tenure

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Graph of editorial queue lengths for journal ACM TOPLAS.

Queueing Environment



Allow Customers to Use Time Creatively or Effectively

- Diversions
 - “Mirrors”
 - “Silent Radio” from Los Angeles
 - “Captive Audience TV from Ohio
 - Manhattan Savings Bank
- MBTA in Boston
- Disney lines

More on What's Happening within the Queue Environment

- Exploit “Queue within a Queue” situations
 - ATM's at Transit Stations
 - Electronic deli counters read out
 - Selling items at intersections
 - Directed advertising on phone wait or internet or on TV
- “Queues are captive audiences”

Our Research @ BankBoston

- ◆ “Prescription for the Waiting-in-Line Blues: Entertain, Enlighten, and Engage”
 - Karen Katz, Blaire Larson & Dick Larson
 - *Sloan Management Review* 1991
- ◆ 3 treatments: status quo, electronic queue wait estimator, and Silent Radio
- ◆ Video observations and matched exit interviews

Information Regarding Delay



Managing Customers' Expectations: Announcing Delay Estimates

- ◆ Disney
- ◆ Elevators
- ◆ Restaurants
- ◆ Police 911 call for service
- ◆ Aircraft delayed prior to takeoff
- ◆ Electronic Line Monitoring Technology

Shroud of Turin

1978: queue wait = 16 hours

1998: queue wait = 0 hours, thanks to
phone & Internet
reservations

NY Times p. 1, 4/19/98

Guarantee a Maximum Possible Delay:

Good for Image and Market Share

- ◆ Pizza chains (Domino's, Papa Gino)
- ◆ Chemical Bank's "547" program
- ◆ Bank of America's "545" program
- ◆ Private Hospital's 5 minute delay guarantee (or 25% off!)
- ◆ McDonald's breakfast promo:
"Breakfast in a Minute, a Minute Guaranteed"
- ◆ Businessperson's lunch guarantees now in numerous restaurants

Social Justice in Queues



Attempt to Preserve “Social Justice” in Lines

- ◆ Single serpentine lines
(Chemical Bank, Chase Bank,
American Airlines, Wendy’s)
- ◆ Wendy’s Denny Lynch: On why all Wendy’s
restaurants are single-file serpentine lines
 - **“We started that way because Wendy’s founder
Dave Thomas didn’t like to be bumped out of
lines.”**

More on Social Justice

- ◆ Hotel lobby examples
 - ORSA/TIMS Convention check out
- ◆ Pulling a gun in Lakeland, Florida
- ◆ Supermarket express lanes: deemed fair within purchase limits!
 - Milwaukee 4/8/98 (*USA Today* 4/13/98): One customer is irritated that another in front has “too many items”, pulls out knife and cuts off half her nose!
- ◆ Driving in traffic - more on that in a bit

Social Justice

Usually a violation of FIFO:
Sears Problem

Leads to new physics quantities:

Slips and Skips in queues

Ph.D. thesis: Ethel Sherry Gordon

Social Justice is Often More Complicated Than FCFS

- ◆ Hospital emergency rooms
- ◆ Organ transplants
- ◆ Danish ferry queue example

Some Other Nonstandard Aspects of Queues



↓ λ : Avoid Queues: Use Alternate Procedures

- ◆ Express check-in and check-out (hotels, rental cars)
- ◆ Pay bills by mail, not in person
- ◆ Don't visit Registry of Motor Vehicles, do business by mail
- ◆ Travel-agency-issued boarding passes

$\bar{\mu}$: Use Technology to Speed Service

- ◆ ATM's for Banks (1:3 in cost/transaction)
- ◆ Bar code scanners
- ◆ ATM-like order taking machines (Burger Kings, Illinois Facility)
- ◆ Automated parking lot attendants
- ◆ Ticket producing machines (airports)

Make the Customer the Server!

- ◆ Supermarkets
- ◆ Gasoline “service” stations
- ◆ Burger King Soft Drinks
- ◆ WWW buying and selling

8 Minutes of Fame! ABC's *20/20*



Promising New Research Beyond Queueing Physics

- ◆ Road Rage
- ◆ Organ Transplants
- ◆ Public Housing
- ◆ For queue dwellers:
 - Advertising
 - Entertaining
 - Educating

Image removed due to copyright restrictions.
Diagram of "The Cutoff" lane change maneuver.
From Gershkoff, I., and R. Trachtman. *Wild in the Streets:
The Boston Driver's Handbook*. Da Capo Press.

Road Rage is Epidemic

- ◆ 7/18/97 CNN -- For the fourth year in a row, the death toll on America's highways climbed in 1997, thanks mainly to a new malady known as "road rage." More than 41,000 died in traffic accidents, according to the National Highway Traffic Safety Administration (NHTSA). The gov. agency says that 2/3 of those deaths were the result of road rage. (How do they know?)
- ◆ The rate of "aggressive driving" incidents--defined as events in which an angry or impatient driver tries to kill or injure another driver after a traffic dispute--has risen by 51 % since 1990. In those cases studied, 37 % of offenders used firearms against other drivers, 28% used other weapons, & 35% used their cars.
- ◆ Road rage is driving Britain to distraction (John Langley). ALMOST 3/4 of drivers have been the victims of road rage.
- ◆ Loud complaints about Road Rage in Israel.
 - see for ex. <http://www.jsonline.com/forums/rage/messages/200.htm>

Queue Etiquette is Often Linked to Road Rage Incidents

- ◆ Wherever there's merging traffic, follow the rule "Let one in and go"; one of several tips in U.K. safety booklet
 - <http://www.theaa.co.uk>
- ◆ One trivial incident, such as one car cutting in front of another car, can serve as a spark that taps into a reservoir of anger, hostility, and frustration.

– <http://www.bhcs.com>



The Public is Being Educated

Campaign Hopes to Curb Road Rage in US

Maryland: A new series of drive-time public service announcements aim to shame drivers into reintroducing courtesy to their driving.

In one of the spots an old lady has trouble finding her pen when she goes to cash a check at the bank. ``Come on, lady, get a move on, where did you learn to bank anyway?'' yells a male hothead in the line. A similar scene is played out in the reception line of a wedding where a guest cuts in.

Time (Tim Dobbyn)

<http://www.pathfinder.com/news/latest/RB/1998Feb18/700.html>

Road Rage: The Terminal State in the Psychology of Queueing

Time for Some Serious OR/MS
Research!



US Presidential Elections: Queue Wait Equity

Columbus, Ohio 2004

Photos removed due to copyright restrictions.

Afgan Presidential
Election 2004

Zimbabwe Presidential
Election 2002

http://watch.windsofchange.net/afghan_election.htm

http://news.bbc.co.uk/cbbcnews/hi/world/newsid_1863000/1863842.stm


http://www.news24.com/News24/World/US_Elections/061192-10-1665_1614612.00.html

4.US Presidential Elections: Queue Wait Equity

- ◆ 2004 Ohio: Up to 10 hour voter queues reported in Columbus, Cincinnati, Toledo
- ◆ **Potential votes may not vote due to long lines: balking and renegeing**
- ◆ **Barbara Boxer: *“Why were voters at one precinct, for example, made to wait in line until nearly 4 a.m., 4 in the morning, to vote because there were only two machines? At Kenyon College, there were 1,300 voters. They needed 13 machines, they had two.”***
- ◆ Proposed research to create equitable voting machine deployment system based on queueing models and implemented with awareness of social science and management issues.

Image removed due to copyright restrictions.
Excerpt from Belensky, A. S., and R. C. Larson.
"Voting shouldn't require a heroic act of patience."
Christian Science Monitor, Sept. 12, 2006.

Take-aways from Queue Psychology

- ◆ It's not how long you wait, but how you experience the wait.
 - ◆ Adjusting the queue environment can have huge payback
 - ◆ There is a social justice in queueing that often favors First Come, First Served
 - ◆ Queued customers represent a captive audience
- 

Take-aways from Queue Psychology

- ◆ Avoid queues by finding alternatives
- ◆ Exploit queues within a queue
- ◆ Be creative!
- ◆ Have the customer provide her own service
- ◆ Announce delays
- ◆ Use service time guarantees
- ◆ **Be careful! Bad queues can be hazardous to your health!**

Some More General Take-Aways

- ◆ Considering the non-mathematical aspects of queues can - interestingly - lead to new mathematical challenges
- ◆ Let's welcome left-brain/right-brain thinking in OR/MS
- ◆ There's a lot more to queueing than the next paper on steady state analysis of some toy problem
- ◆ Broadly defined problem-driven research: fertile ground for new queueing work

Oh, the telephone dial tone....?

