Allocating resources to improve voting

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For the Presidential Commission on Election Administration

September 4, 2013

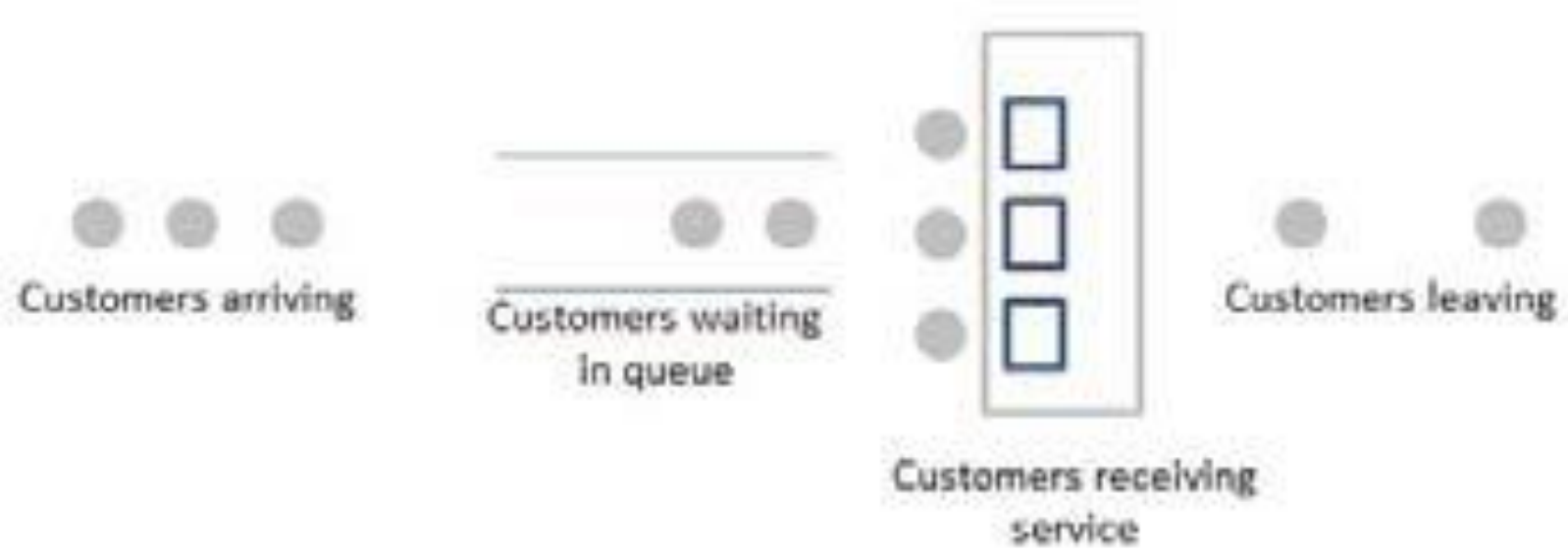
- Long lines occur when resources are inadequate
- Yet resources are inevitably constrained
- Managers must decide how best to allocate resources to get best overall performance
- Tools exist to help managers understand the trade-offs and make these decisions

- How best to allocate a given number of machines or staff across a set of precincts?

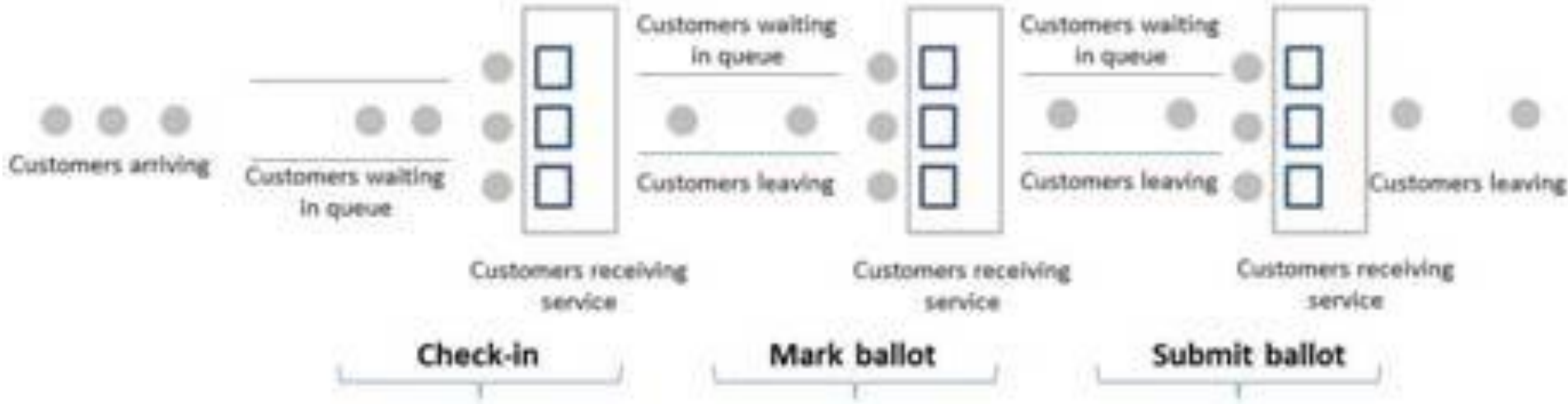
- How many machines (staff) are needed in each precinct to achieve a waiting time service target?

- What if's? How do the answers depend on various estimates and assumptions?

Queuing Theory



Voting as a queuing system



- Demonstrate capabilities of a simple spreadsheet tool
- Relies on “text-book” queuing models
- Could be incorporated into an optimization or search algorithm
- Should be coupled with simulation tool that can validate, examine more carefully impact of daily dynamics, and help with detailed planning

Screen Shot of Resource Allocation Tool

Inputs in Yellow

Outputs in pink

Managerial Parameters

X = max-wait-time target (seconds)	180	registration service time (seconds)	20
Y = service level	90%	Target percent for no registration wait	80%

precincts	peak arrival rate (voters per hour)	average time to vote (minutes per voter)	number of voting stations/machines	System Stability?	average waiting time (seconds per voter)	Percent wait time greater than X	# of machines req'd to meet service level	wait time reduction from one more machine (seconds per voter)	number of people needed to assure no/modest waits
1	100	10	22	OK	17.42	3%	20.33	7.88	1.44
2	150	10	28	OK	91.46	19%	29.04	40.30	1.79
3	200	10	35	OK	250.74	42%	37.65	126.57	2.11
4	75	10	22	OK	0.66	0%	15.89	0.35	1.25
5	80	10	22	OK	1.42	0%	16.79	0.73	1.29
6	120	10	22	OK	170.37	31%	23.83	87.23	1.58
7	220	10	38	OK	342.30	51%	41.08	184.95	2.23
8	120	10	22	OK	170.37	31%	23.83	87.23	1.58
9	180	10	35	OK	34.15	6%	34.22	12.96	1.98
10	90	10	22	OK	5.43	1%	18.56	2.58	1.37
totals			268						16.62

Example

- 3 precincts, 15 machines to allocate
- Average time to vote = 6 minutes
- Service target: max wait time of 3 minutes
- Focus on peak period
- Inputs:

precinct	arrival/hr
1	25
2	35
3	45

Suppose we allocate equally:

precinct	arrival/hr	machines	ave wait time (sec's)	% wait more than 3 min's
1	25	5	19	4%
2	35	5	91	18%
3	45	5	549	59%

Can we do better?

Can we improve the allocation?

precinct	arrival/hr	machines	ave wait time (sec's)	% wait more than 3 min's
1	25	4	77	15%
2	35	5	91	18%
3	45	6	101	20%

precinct	arrival/hr	machines	ave wait time (sec's)	% wait more than 3 min's
1	25	3	506	55%
2	35	5	91	18%
3	45	7	31	6%

What if we have one more machine?

What's the value from more resources?

precinct	arrival/hr	machines	Reduction in wait (sec's)
1	25	4	58
2	35	5	65
3	45	6	70

precinct	arrival/hr	machines	ave wait time (sec's)	% wait more than 3 min's	Reduction in wait (sec's)
1	25	4	77	15%	58
2	35	5	91	18%	65
3	45	7	31	6%	21

Suppose we want at most 10% of voters to incur waits more than 3 minutes

precinct	arrival/hr	required machines
1	25	5
2	35	6
3	45	7

precinct	arrival/hr	machines	ave wait time (sec's)	% wait more than 3 min's
1	25	5	19	4%
2	35	6	26	5%
3	45	7	31	6%

Suppose we re-design the ballot so that the time to vote is reduced from 6 to 5.4 minutes:

precinct	arrival/hr	machines	ave wait time (sec's)	% wait more than 3 min's
1	25	4	45	9%
2	35	5	48	10%
3	45	6	49	10%

Check-In

- Similar analyses apply here, e.g.
  - Suppose average check-in time = 0.5 minutes
  - How many stations are needed so that no more than 20% of voters experience a wait at check-in?

precinct	arrival/hr	required stations
1	25	1
2	35	2
3	45	2

- Analysis accounts for (& can compare)design of check-in : single line or multiple lines?

Summary

- Waiting occurs due to inadequate resources
- This can occur due to insufficient system resources or due to poor allocation.
- Tools based on queuing theory can provide guidance to improve resource allocation and to determine resource requirements
- Tools require inputs: arrival rates; time to vote; and service targets
- Tools should be deployed with tutorials and with capabilities for detailed simulations