

Dr. Chun's Numb3rs & Løgic

The Curse of Variation



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Bus Paradox



From Nico M. van Dijk, "To wait or not to wait: that is the question."
Chance Magazine, Vol. 10, Winter 1997 p. 38.

- **Case 1:** Suppose that **buses** arrive exactly **every 20 minutes** at your corner (i.e., the times between arrivals are **20, 20, and 20** in an hour).

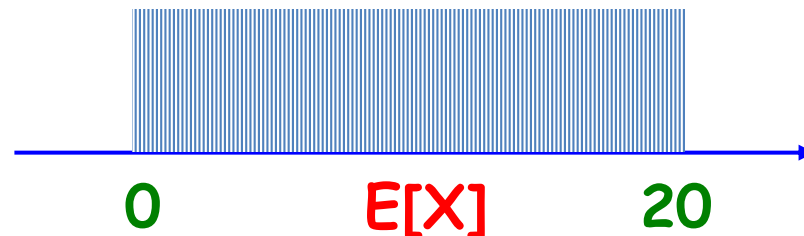


(a) What is the *average time between arrivals*?

$$(20 + 20 + 20)/3 = 20 \text{ minutes}$$

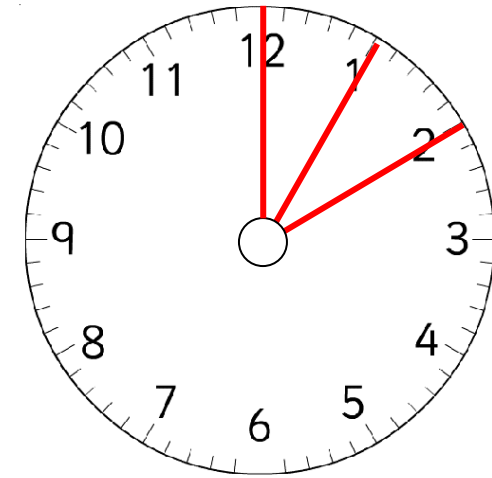
(b) If you arrive at a random time, what is the *average waiting time*?

$$(0 + 20)/2 = 10 \text{ minutes}$$





▪ **Case 2:** The slight **variation** in the arrival times, keeping the same average of **20 minutes** between buses, can increase your **average waiting time significantly**. For example, suppose that the times between arrivals are **5, 5, and 50** in an hour.

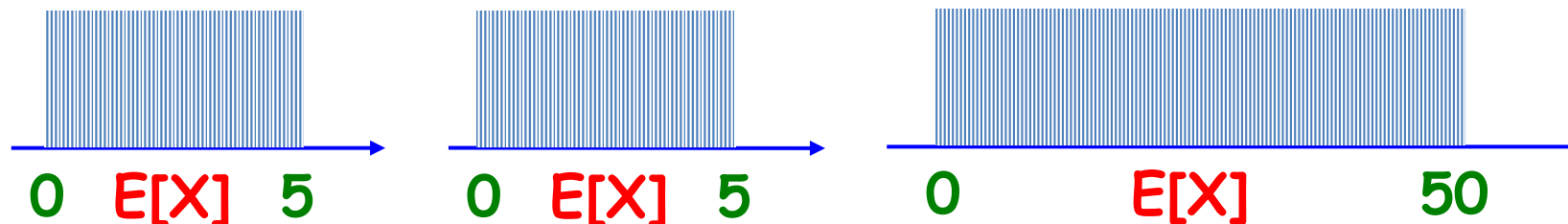


(a) What is the **average time between arrivals**?

$$(5 + 5 + 50) / 3 = 20 \text{ minutes}$$

(b) If you come at a random time in this hour, what is the **average waiting time**?

$$5/60 \times 2.5 + 5/60 \times 2.5 + 50/60 \times 25 = 21.25 \text{ minutes.}$$





- **Comparison**

	Case 1	Case 2
Number of buses	3 buses an hour	3 buses an hour
Arrival pattern	20, 20, and 20 min	5, 5, and 50 min
Average arrival time	20 minutes	20 minutes
Average waiting time	10 minutes	21.25 minutes

- **Curse of variation**

- "When it rains, it pours."
- Speed on interstate highway

- **Blessing of no variation**

- Running back: **Exactly** 3 yards per carry





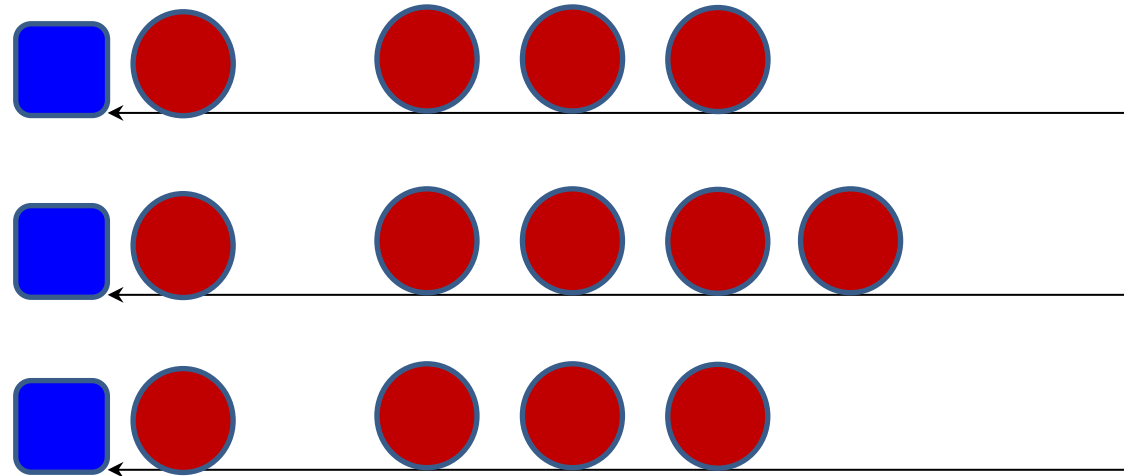
- **No waiting line at the barber shop!**
 - **Service rate** = **Exactly 10** customers per hour!
 - **Arrival rate** = **Exactly 10** customers per hour!
- **Why do we have to wait?**
 - **Service rate** is a **random variable** with a large **variance**.
 - **Arrival rate** is also a **random variable** with a large **variance**.
- **How to shorten the waiting time?**
 - Increase the **service rate**:
 - Hire more bartenders during the **peak hour**.
 - Control the **demand rate**:
 - Reservation, early bird special, happy hours.
- **Waiting line model** in Service Management
 - **Queueing** theory (5 vowels in a row!)



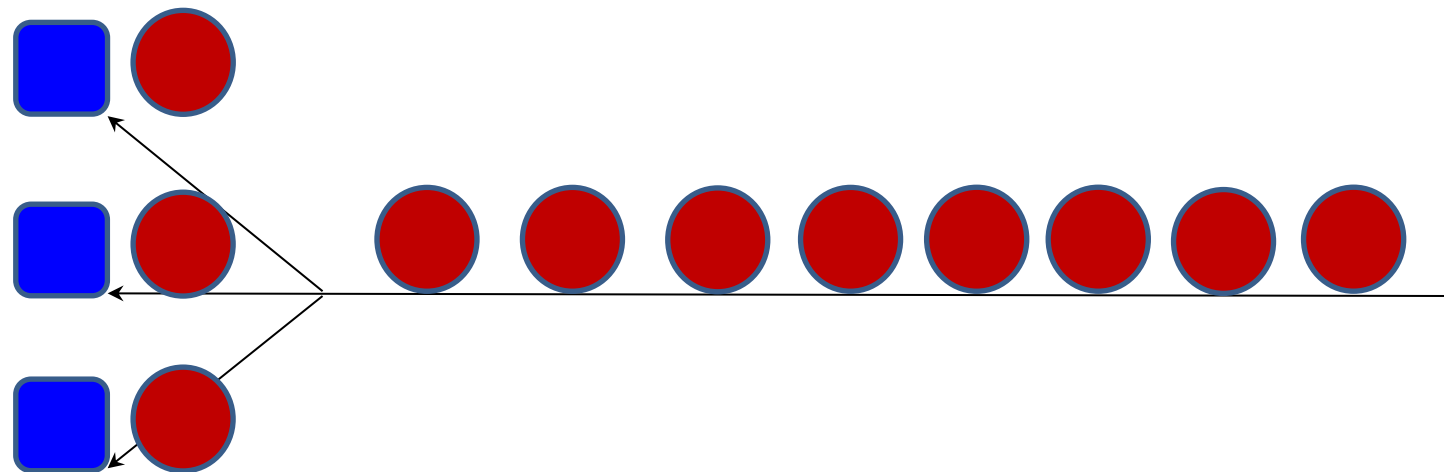


- Example of the queueing model: Which **setup** is faster?

(a) **Multiple lines** and **multiple registers**



(b) **Single line** with **multiple registers**



Movie Trivia



A **young cop** must prevent a **bomb** exploding aboard a **city bus** by keeping its speed above 50 mph.

Speed (1994)



A **young cop** must prevent a **bomb** exploding aboard a **city bus** by keeping its speed above 50 mph.