Inventory Modelling Using SimPy

By Jimmy McLaughlin, Mengzhe Zhang, and Professor Anh Ninh

Outline

- Overview of inventory management
- Research goal
- Modelling
  - Trade offs
  - Poisson process
  - Inventory policy
- Simulation in SimPy
- Results

Importance of inventory management

- Accurate Track of items
- Avoiding Stockout
- Timely balance supply and demand
- Working capital Issues
- Customer Retention

Inventory management in practice

- Most widely used---spreadsheets, Access, SAP one, Syspro

- Bar codes and scanners- Universal Product Code (UPC) and personal computers made this possible for groceries

Entities that use inventory management

Goods Based Companies: Apple, Nike, Gopro

Service Based Companies: JP Morgan, Deutsche Bank

E-Commerce Companies: Amazon, Alibaba

Retailers: Walmart, Costco

Manufacturer: Foxconn, Pegatron


Generate SR with
Barcode Scanner Also
Warehouse
Warehouse
Generate SR for
Received Goods
Customer
Request for Customer
Ordered Qty.
Supply Ordered Goods
Supplier
Create PO for Back
Order / Low Stock Goods
Place Order
Your Store
Ship Customer Order
Maintain Store
Inventory Log
Inventory Log

Research goal

Find the most efficient way to manage inventory in a simplified supply chain network with only a single store **over a given time period**

How to characterize random demand?

What are the decision making criteria?

What is the best inventory policy?

Trade-offs in inventory management

Type of Cost

Shipping

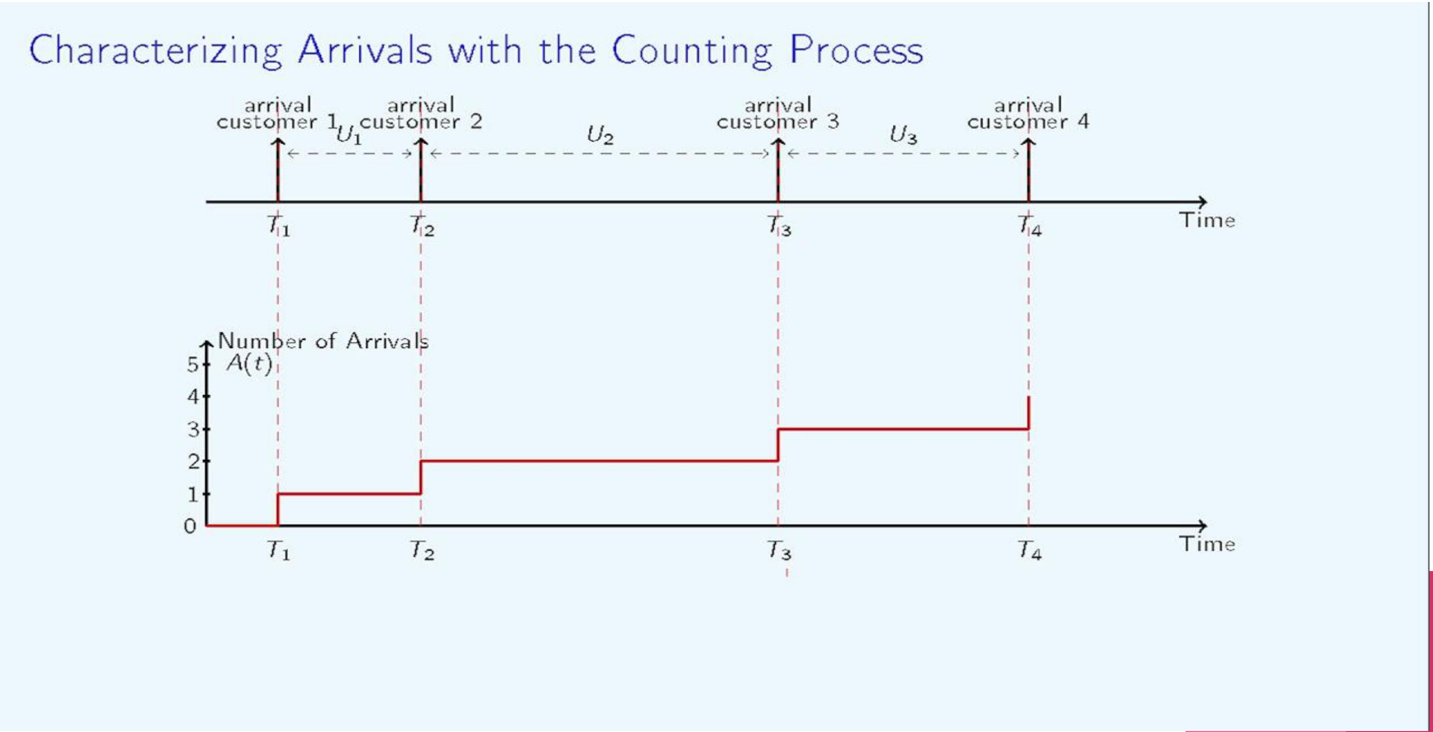
Holding

Backorder

Goal

Find the optimal policy to minimize three costs combined

Customer arrivals: Poisson process



Customer arrivals: Poisson process

- Given an arrival rate r, the probability of having k events in an interval t is given by:

$$P(k \text{ events in interval } t) = e^{-rt}\frac{(rt)^k}{k!}$$

- The inter-arrival times follow an exponential distribution with mean 1/r

Inventory policy

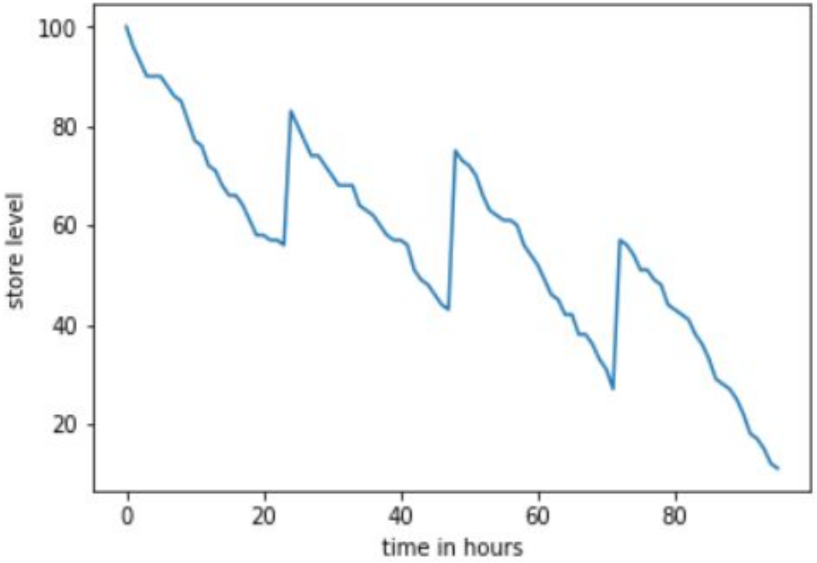
Constant delivery policy

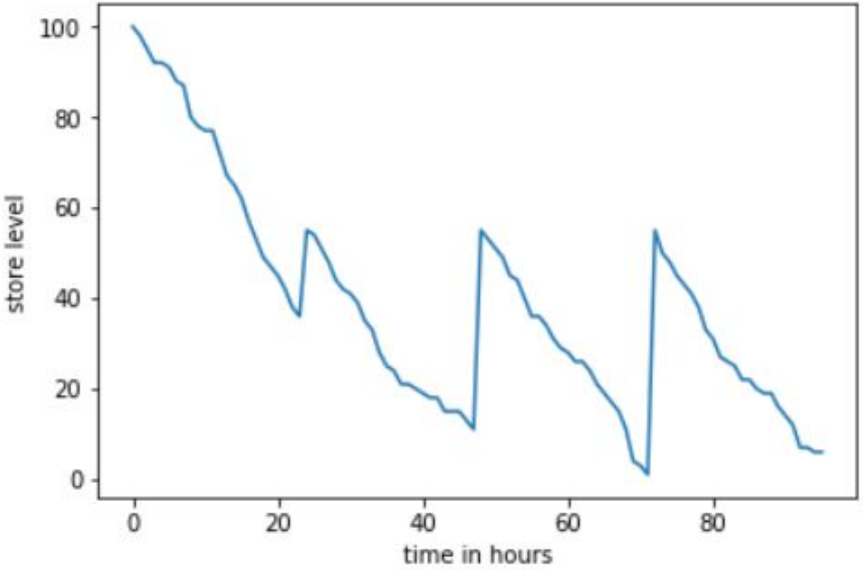
order the same number of units every day regardless of current inventory level

Order up to policy

order just enough so that we start every day with the same amount of items

Policy 1 Versus Policy 2





Research questions: recap

- Which ordering policy is more cost efficient?
- If policy 1 is better, what is the ideal delivery amount?
- If policy 2 is better, what is the ideal order-up-to amount?

Brief introduction of SimPy

- “SimPy is a process-based discrete-event simulation framework based on standard Python” -from SimPy website
- Useful for models where we want to keep track of time
- Yielding an event causes the process to get suspended, and the process will resume once the event occurs.
- SimPy is relatively new; its first release was in 2002 and the current version was released in 2016.

Simple example

```
def car(env):
    while True:
        print('Start parking at %d' % env.now)
        parking_duration = 5
        yield env.timeout(parking_duration)

        print('Start driving at %d' % env.now)
        trip_duration = 2
        yield env.timeout(trip_duration)
```

-from the SimPy website

Car generator output

```
Start parking at 0
Start driving at 5
Start parking at 7
Start driving at 12
Start parking at 14
```

Applying SimPy to our problem

- For our example, we kept the three costs constant
- Holding cost=$8 per item
- Shipping cost= $50+$20 per item
- Backorder cost=$92 per customer

Applying SimPy to our problem

- Model customer arrival using Poisson process (r=2/hr)

- Every customer takes one item and leaves

- Customer arrival is stationary

Applying SimPy to our problem

- Inventory is reviewed periodically every day
- The simulation runs for 4 days
- Keep track of items in storage, number of deliveries, number of customers that have arrived
- Compute cost at the end of the simulation using the values of our parameters

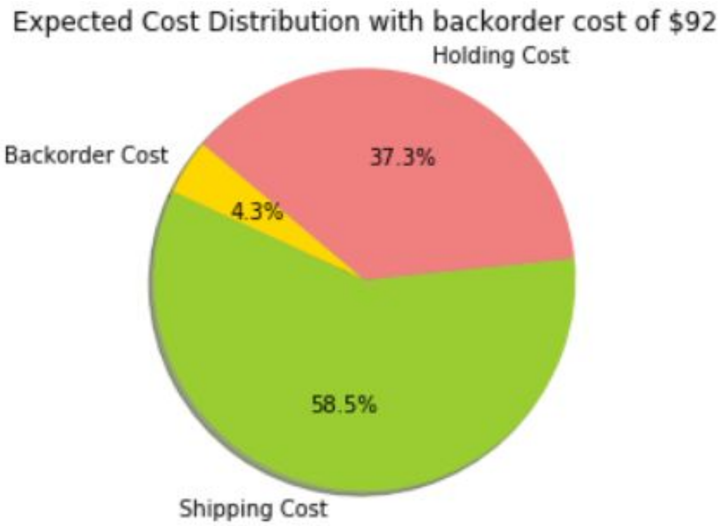
Conclusion

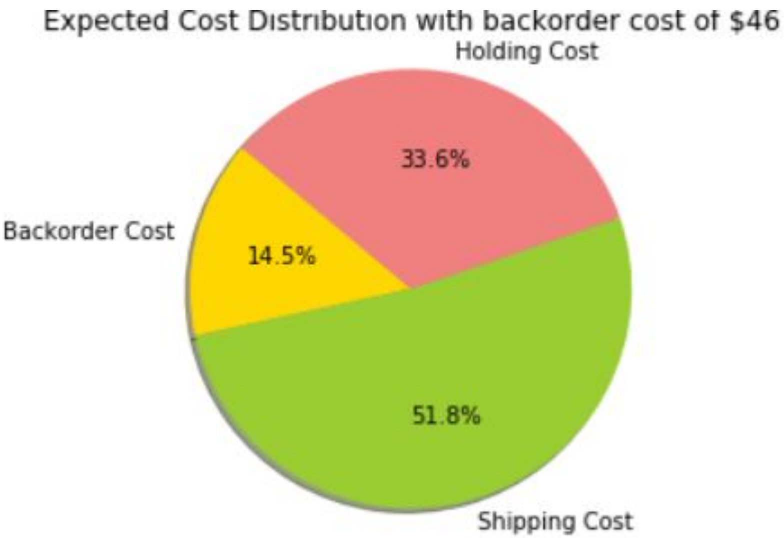
- Strategy 2, the order-up-to policy is the better ordering policy
- The ideal order-up-to amount is 55 items
- The optimal cost for order-up-to 55 items is $3573.929, which is broken down as follows:
- Backlog cost: $152.8764
- Shipping cost: $2089.342
- Holding cost: $1331.71

- For strategy 1, the ideal delivery amount is 32 items per day

Conclusion

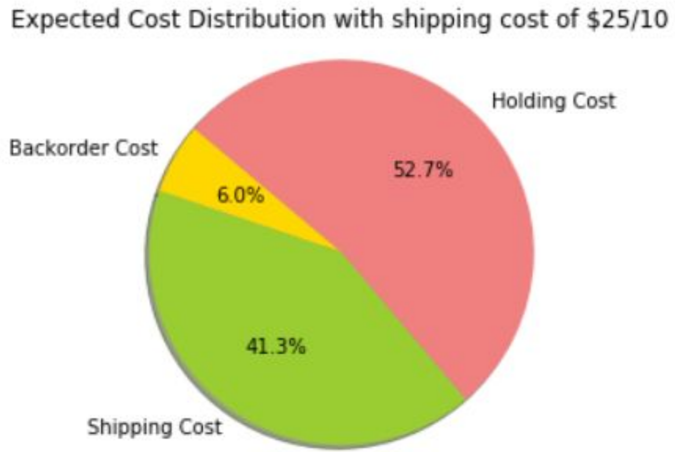
- Trends in changes to backorder cost:
  - If backorder cost decreases, optimal order-up-to amount decreases
  - If we cut backorder cost in half, optimal order-up-to amount becomes 45 items

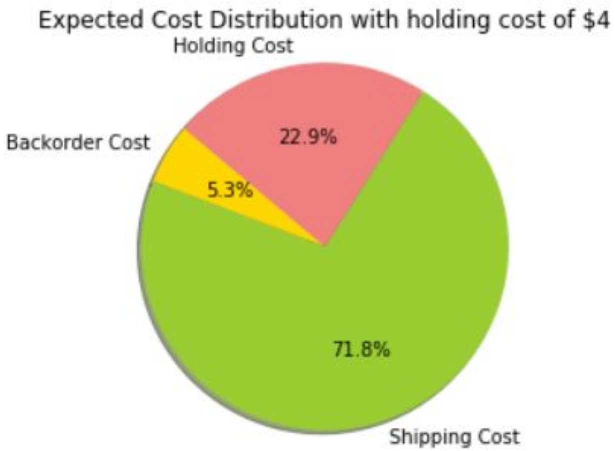




Conclusion

- Trends in change to shipping and holding cost:
  - If we decrease shipping and holding cost, optimal order-up-to amount increases, but not by much unless we increase both
  - In our example, cutting either shipping or holding in half does not change the delivery threshold





Acknowledgements

- Professor Anh Ninh
- EXTREEMS/QED at William and Mary
- National Science Foundation