Key Considerations for Establishing a Framework for Critical Medical Products

Demand Surge, Supply Shocks, and the Critical Role of Supply Chain Design

Nathaniel Hupert MD MPH, Weill Cornell Medicine, Cornell University

John A. Muckstadt PhD, College of Engineering, Cornell University

Peter Jackson PhD, Singapore University of Technology and Design

Michael Klein PhD, San Jose State University

Walt Beadling, Cayuga Partners

Robert Gougelet MD, Global Resonance Technologies LLC

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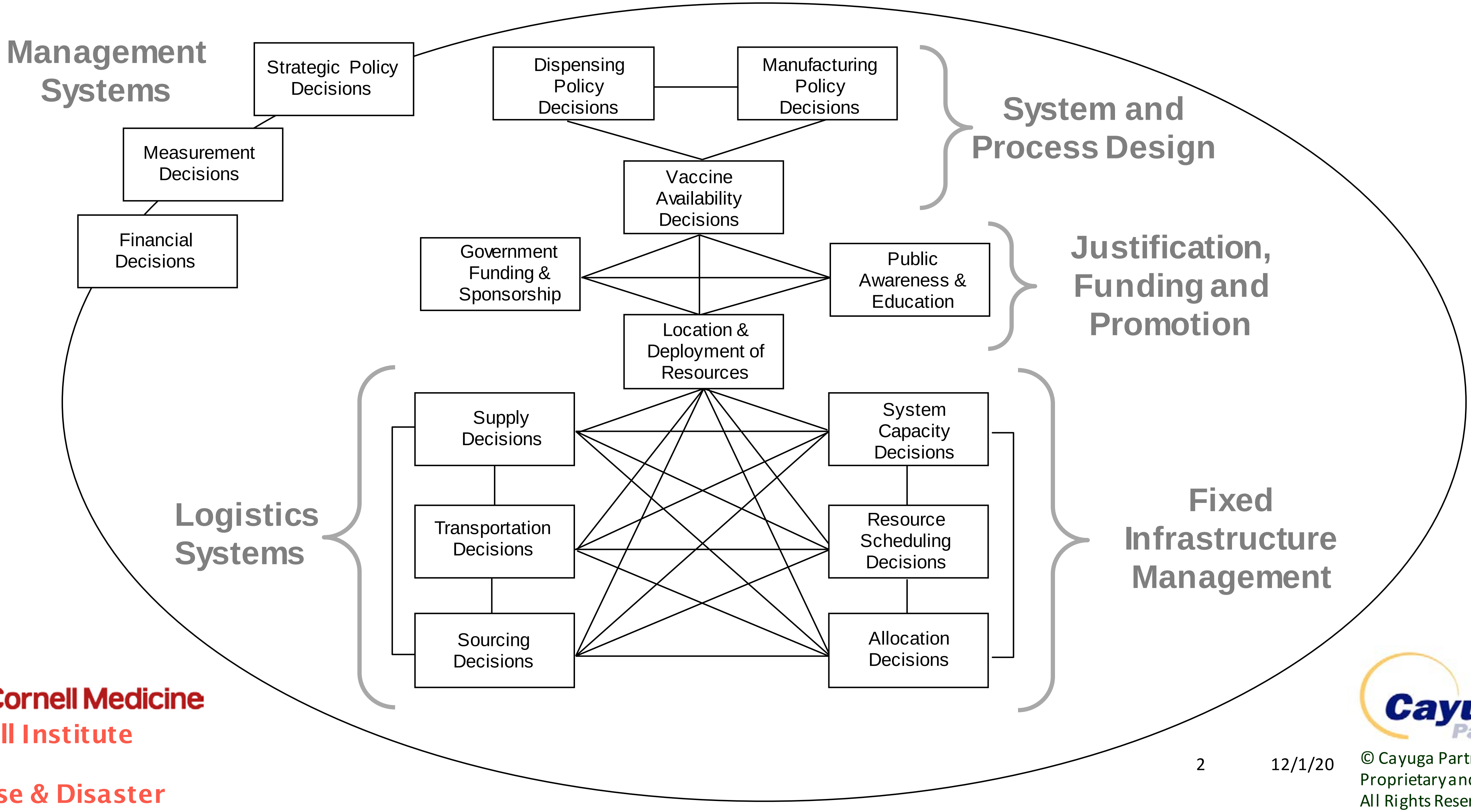
Five Interdependent Systems in a Disaster Preparedness Architecture



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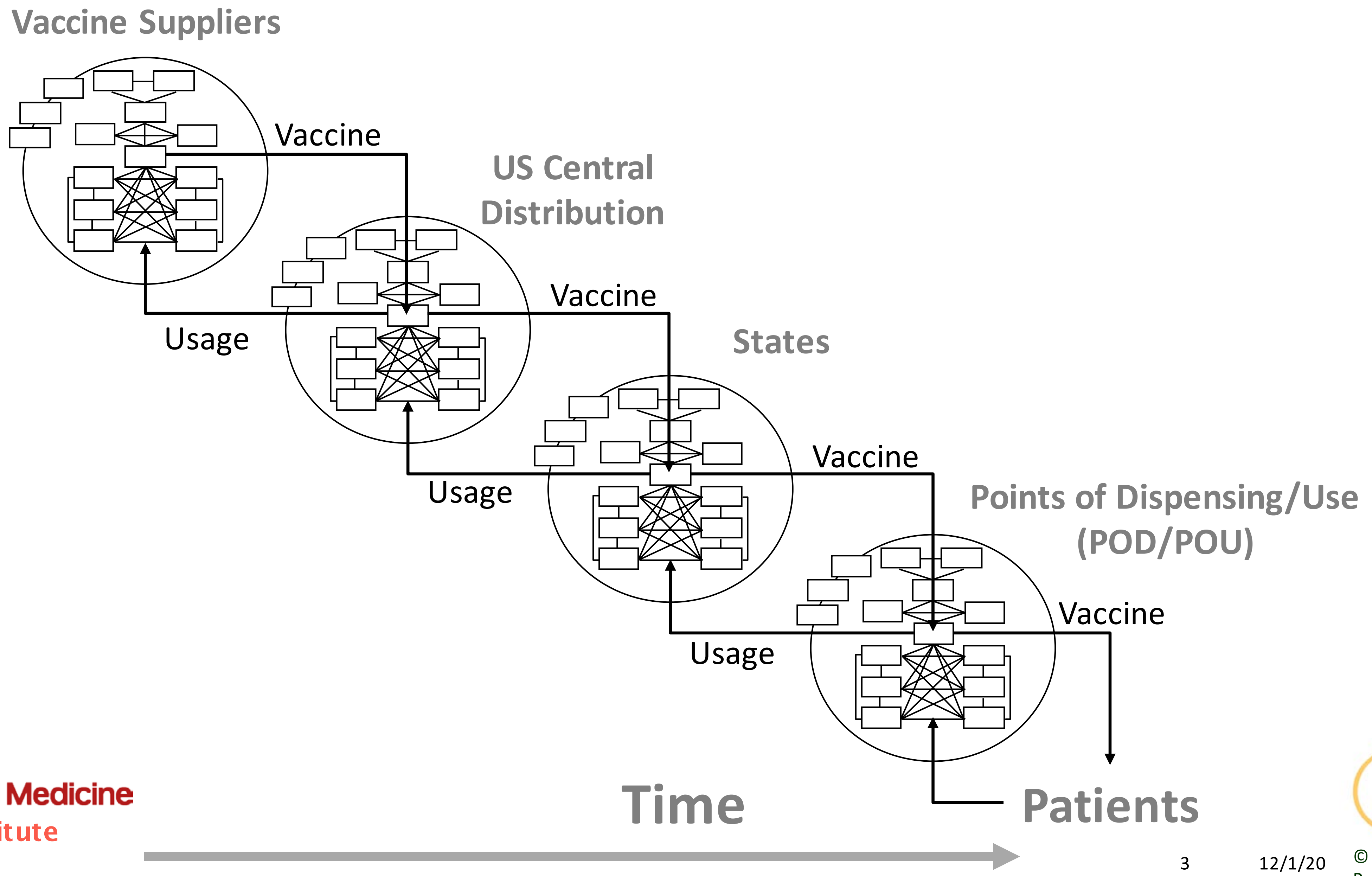
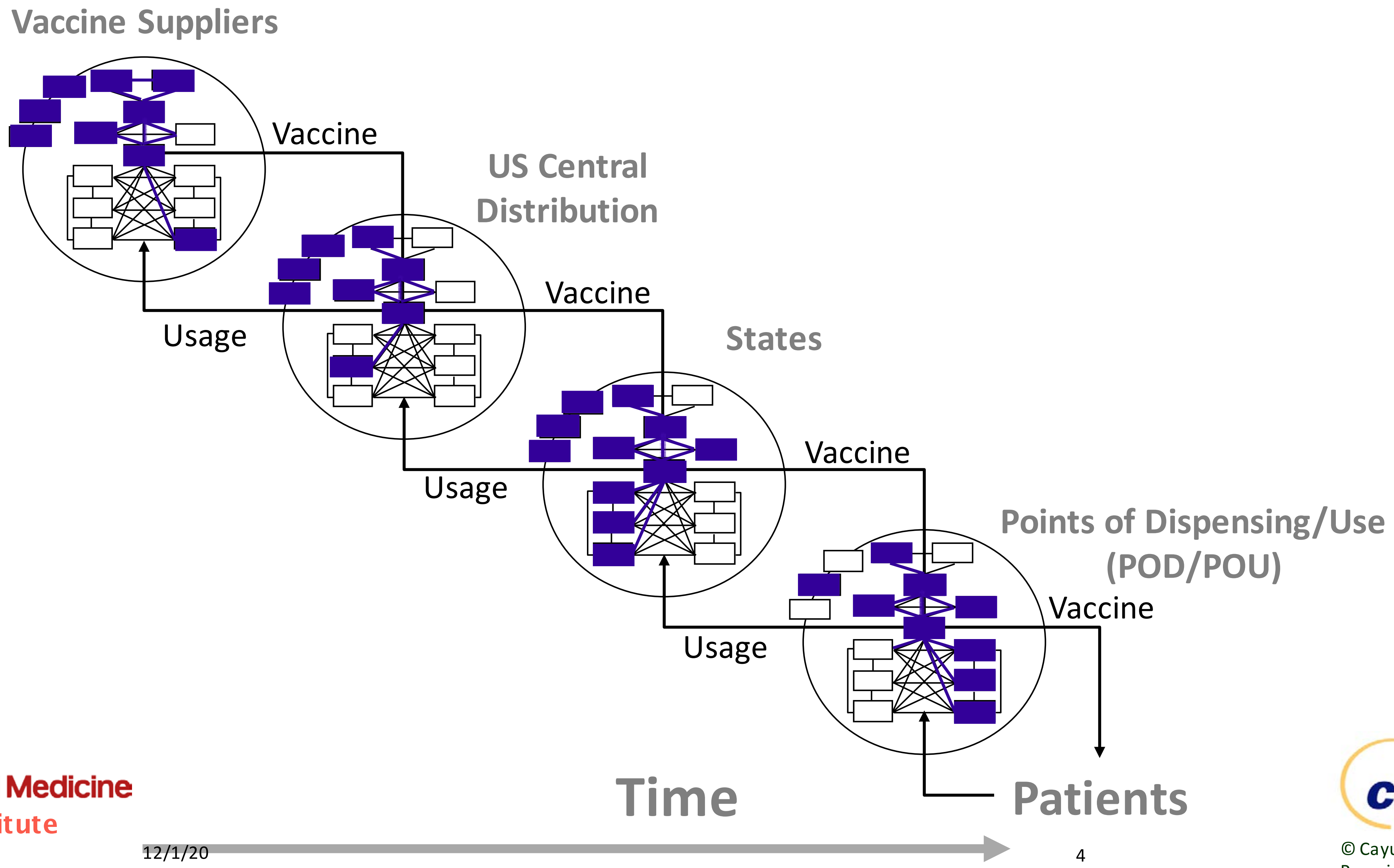
Possible Vaccine Supply Chain System Structure



Vaccine Supply Chain System Structure



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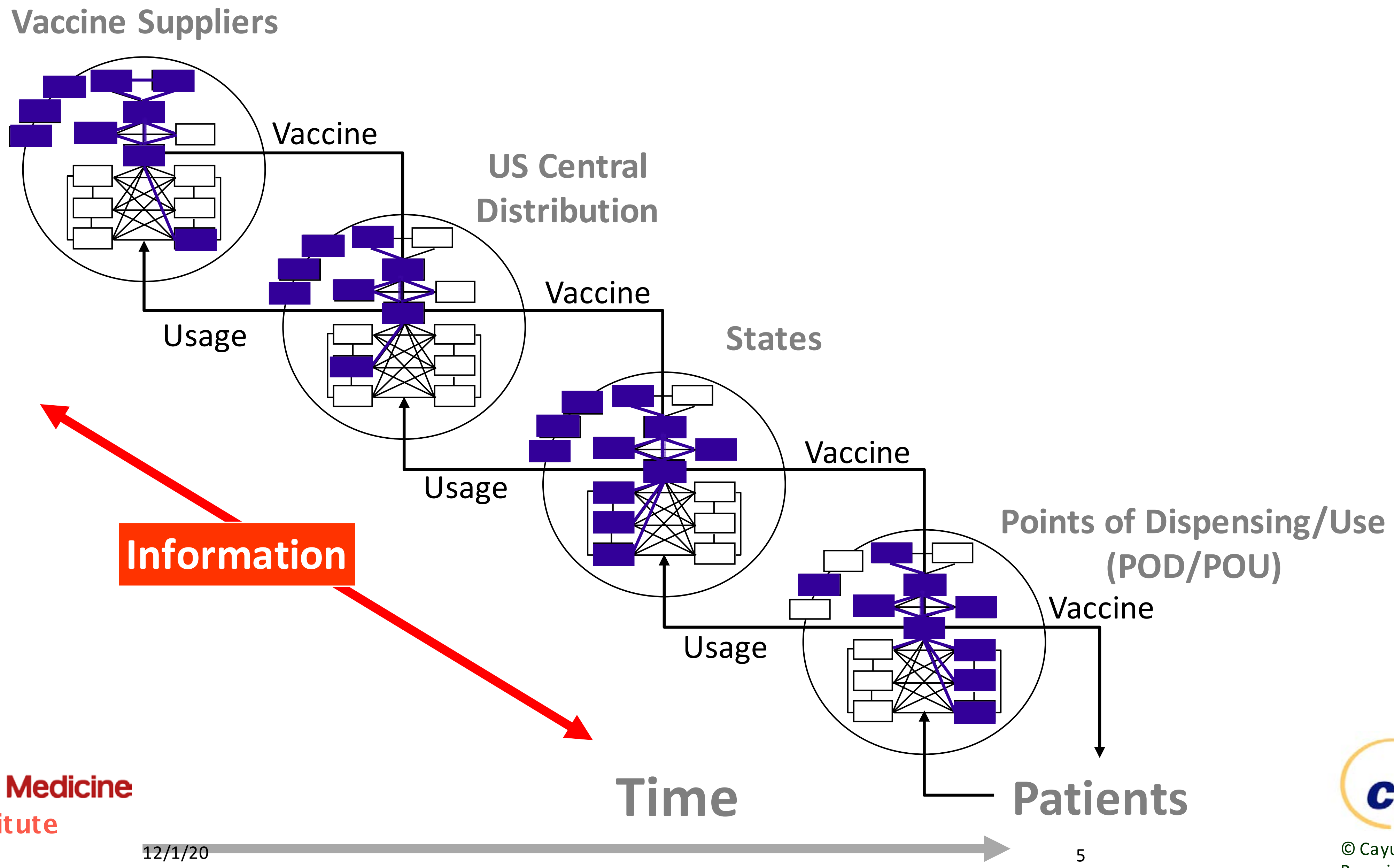
Vaccine Supply Chain System Structure



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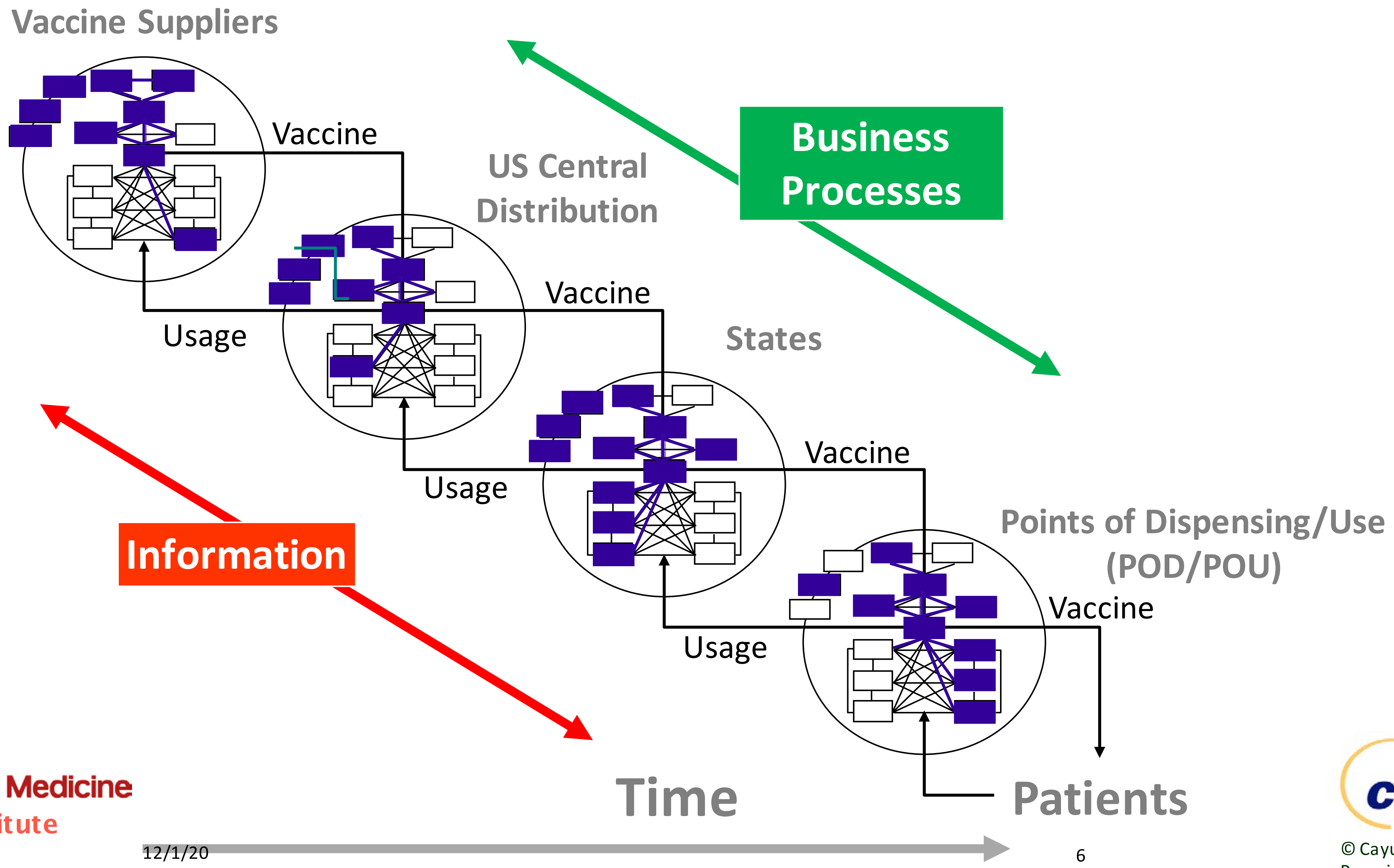
Vaccine Supply Chain System Structure



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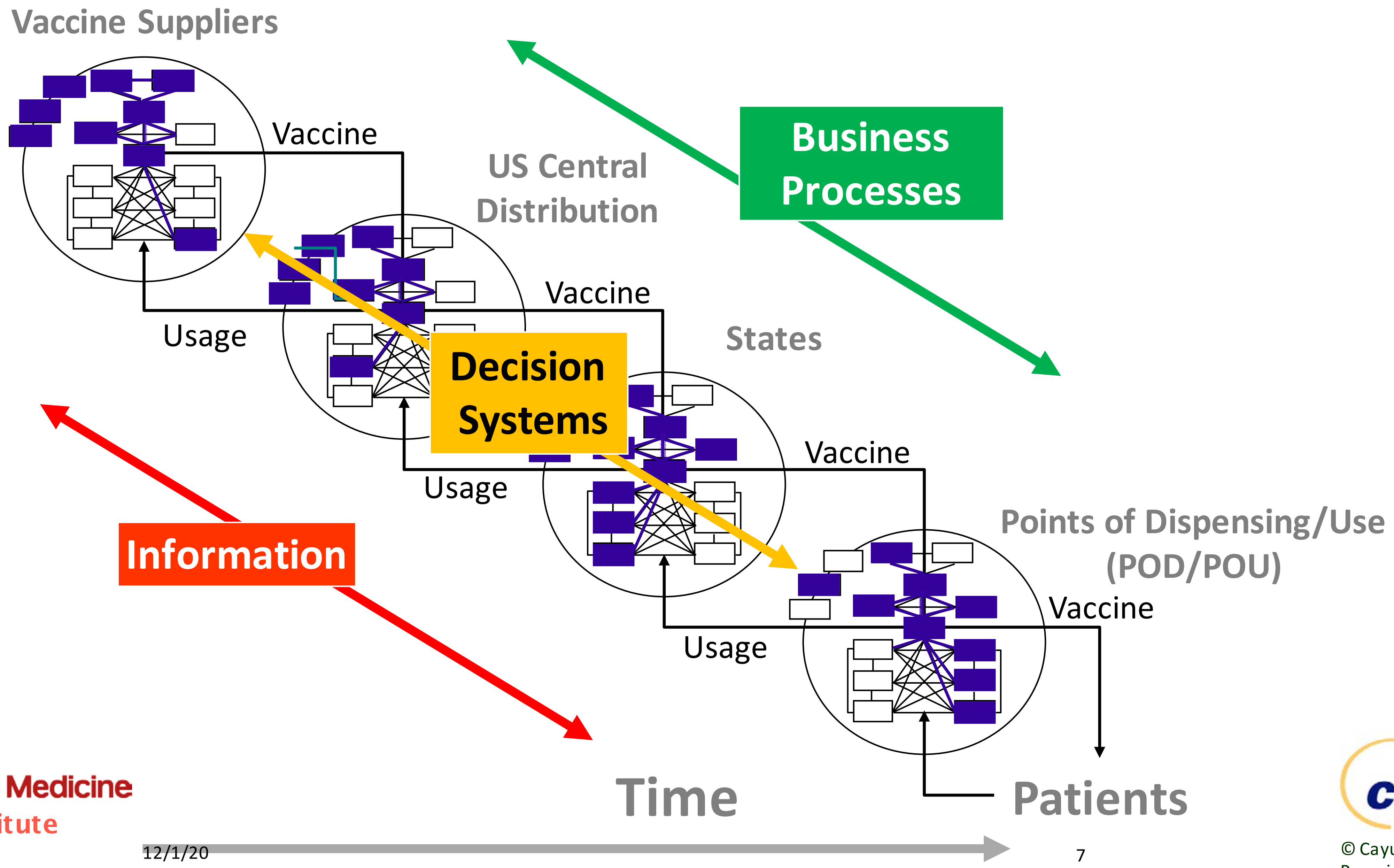
Vaccine Supply Chain System Structure



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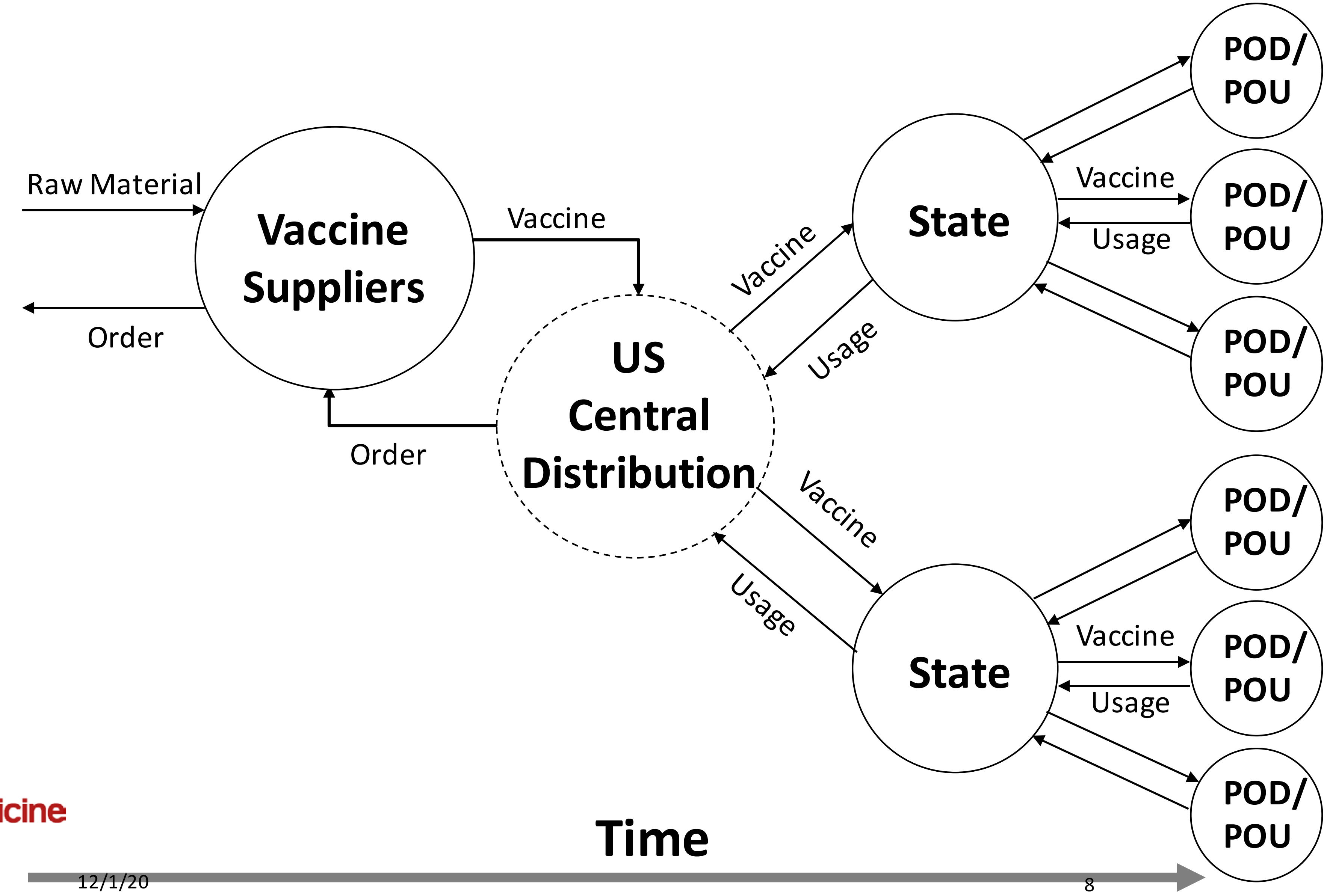
A Visualization of a Possible US COVID-19 Vaccine Supply Chain



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Planning Considerations

- Different vaccine types and requirements
- Cold Chain requirements (-40°C or lower)
  - Logistics (e.g., reefer trailers)
  - POD facility types and capacities
- Reverse logistics and transshipments for returns and reallocation
- Booster shots (2nd inoculation) for some vaccines
- Population profiles and priorities
  - Job description (e.g., healthcare provider)
  - Age category
  - Underlying conditions, etc.

Supply Chain Fundamentals

1. Know *customer requirements:* **vaccine demand vs. State demand**
2. Construct a *lean supply chain organization* that eliminates waste and reduces variability
3. Build tightly-coupled *Information Infrastructures*, both intra- and inter-organizationally
4. Build tightly-coupled *Business Processes*, both intra- and inter-organizationally
5. Construct tightly-coupled *Decision Support Systems* that make supply chain business processes work efficiently and effectively

VTrckS

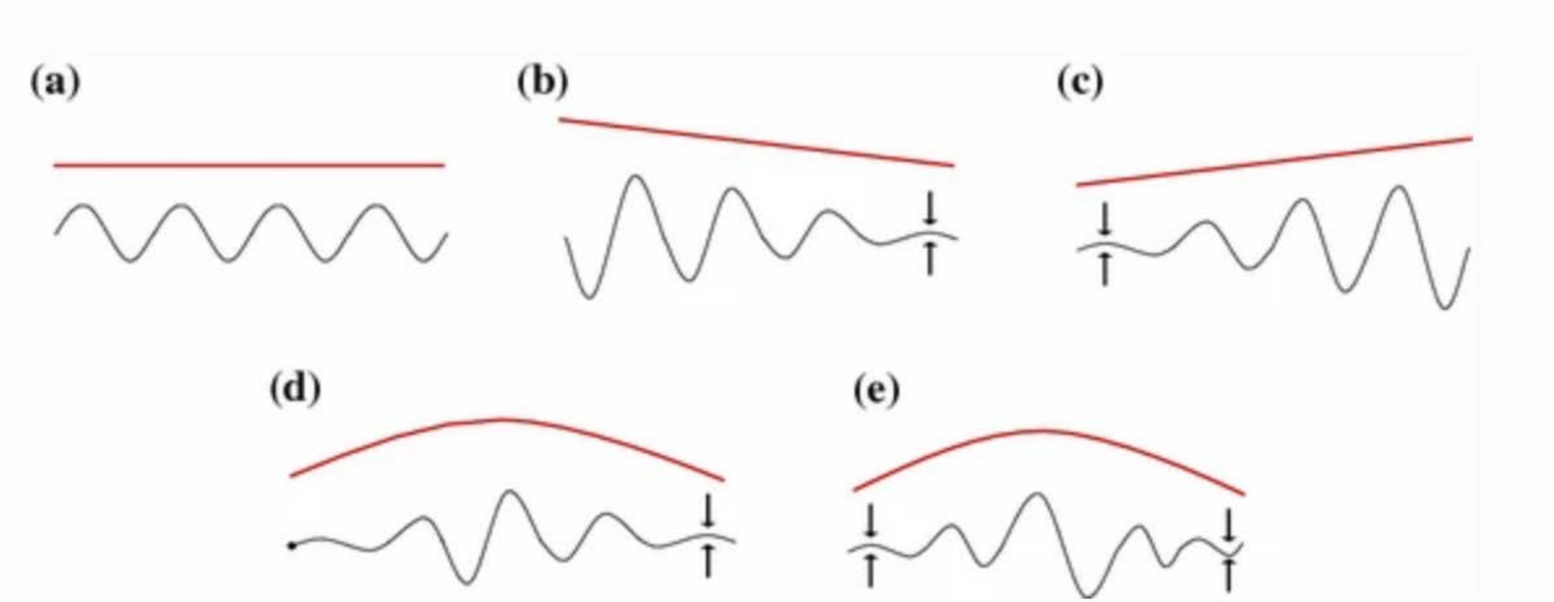
Provider Functionality

- Submit data/documentation for inventory on hand, doses administered, and temperature logs
- Place orders, including direct-ship
- Request priority shipment
- View order statuses, near real-time shipping status, and tracking information
- Place returns, wastage, and transfer orders

Inventory & Distribution

- Communicate with CDC's centralized distributor regarding vaccine inventory and shipment status
- Monitor all inventory movements with near real-time information
- Identify messaging/interface and inventory failures and inventory discrepancies for prompt intervention/resolution
- Provide data to support routine monitoring of distribution performance metrics, including timeliness of provider order fulfillment and bulk order receiving; physical inventory count comparisons; and appropriate use of inventory rotation protocols

VTrckS, The Bullwhip Effect, and the Reverse Bullwhip Effect



String vibrations **a** with no amplification, **b** with a demand vibration and BWE, **c** with a supply shock and RBWE, **d** with a demand vibration, a fixed point, and umbrella pattern, and **e** with a demand vibration, a supply shock, and umbrella pattern. *Thick lines* above strings plot wave amplitude

Rong, Y., Shen, ZJ.M. & Snyder, L.V. The impact of ordering behavior on order-quantity variability: a study of forward and reverse bullwhip effects. *Flex Serv Manuf J* **20,** 95 (2008). https://doi.org/10.1007/s10696-009-9054-3

COVID-19 Vaccine Distribution Model: Demo

COVID-19 Vaccine Distribution Model

- Problem: Plan vaccine allocations to US states from a central stockpile based on projected supply availability, current estimates of the residual (unvaccinated) population and likely distribution profiles
- Objective: Production, allocation and transshipment decisions are made periodically to minimize expected shortages at POD locations
- Method: Computing optimal decisions can be accomplished quickly, on demand
- Assumptions: a network of facilities exists for creating and managing vaccine flow so that:
  - Lead times are relatively short, predictable, and repeatable
  - Each entity in the supply chain has real time knowledge of the inventory levels of all other locations and the quantities of items in transit from and to them
  - Decisions are made frequently based on knowledge of supply chain inventories and the probability distribution of downstream usage over relevant lead time

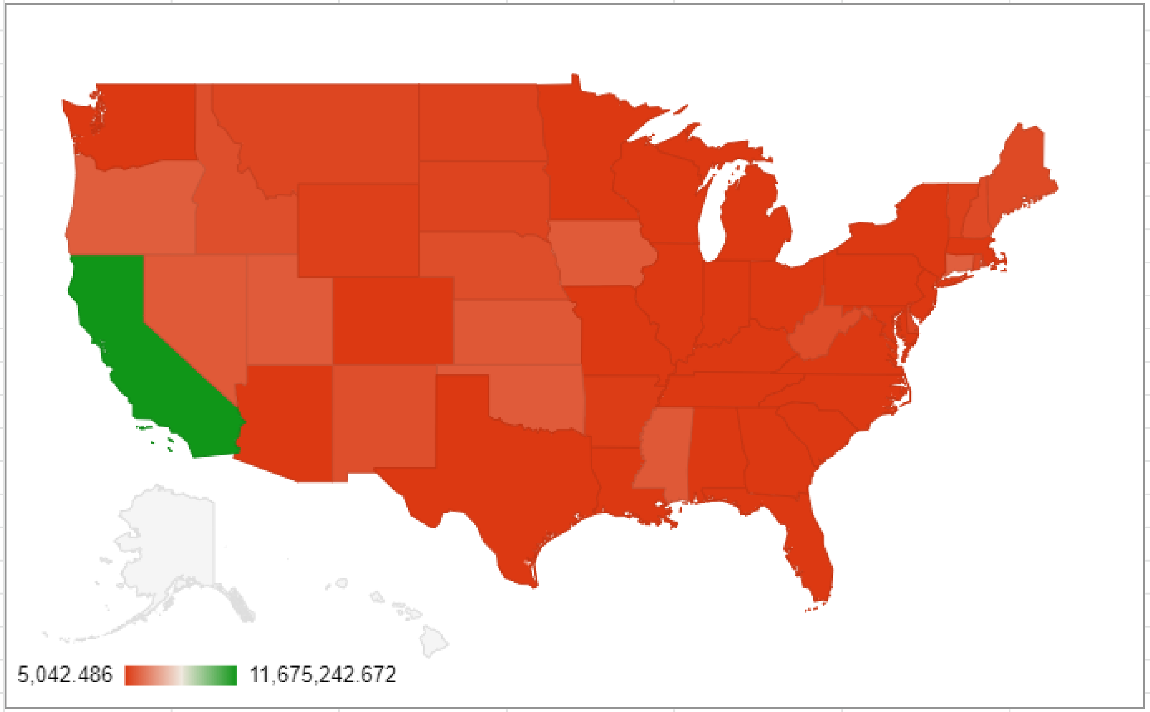
COVID-19 Vaccine Distribution Model (cont'd)

- A stochastic model that determines optimal allocations daily with rolling horizon
- Inputs
  - Dispensing locations (e.g., POD, Primary care office, Pharmacy, etc.)
  - Probabilistic *Usage Profile* (forecast), of usage by POD over several coming days
  - Lead times: Suppliers to Federal government to States to PODs
  - Supply Profile specify the vaccine production into the national stockpile
  - Vaccine supply in all pipelines and anticipated arrival times at each location (GPS tracking)
  - Manufacturing and transportation system's capacity and lead times
- Outputs
  - Planned deliveries showing allocation to each state over coming days
  - Recommended allocation for future on day 1, the basis for action today
  - Expected shortfalls of cumulative backorders by state, by day in the future, assuming a probability distribution of vaccine requirements according to the Usage Profile.
    - Backorder Map: Continental US by state shortfall expected
  - Orders to suppliers and manufacturers

Expected Vaccination Shortfall by Future Day by Dispensing Location

Future Day 12

	Dispensing Location	Expected Backorders (Cumulative)
4	California	11,675,243
6	Connecticut	1,288,525
34	Oregon	1,244,525
33	Oklahoma	1,167,690
41	Utah	1,158,805
13	Iowa	1,140,434
25	Nevada	1,113,388
45	Mississippi	1,075,838
14	Kansas	1,053,153
28	New Mexico	758,340
10	Idaho	754,410
24	Nebraska	699,684
46	West Virginia	663,538
26	New Hampshire	573,798
17	Maine	567,248
23	Montana	450,863
36	Rhode Island	446,884
7	Delaware	410,720
38	South Dakota	373,076
31	North Dakota	321,289
42	Vermont	262,974
48	Wyoming	243,873
3	Arkansas	123,179
40	Texas	12,846
8	Florida	11,056
29	New York	10,522
35	Pennsylvania	8,536
11	Illinois	8,492



Backorder Map

COVID-19 Vaccine Distribution Model: Development and System Support Requirements

- Computational Environment
  - Cloud-based
  - Parallel Computing enabled
  - Data Integration Platform
- Technical support
  - Programming
  - Training
  - Level 1 – 4 user support

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