Cloud Medical Resource Matcher PRD

DEPRECATED, SEE https://onboarding.nationalresponseportal.com/

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Revision History

Ver / Date	*Primary*	*What*
V0.1 Mar 22, 2020	kpb@google.com	Initial Draft (outline structure)

V0.2 Mar 23, 2020	kpb@google.com	Ventilator → Medical Resource
V0.3 Mar 24, 2020	kpb@google.com	Convert google.com → Public Domain, Creative Commons
V0.4 Mar 27, 2020	kpb@google.com	V0.4 Initial Public Domain Version

Contact Information

TBD verify with people the degree to which they want to go public, and convert emails to images for those that are ok.

Darker green highlighted contacts are primary authors.
Light green highlighted contacts are edit authorized.
Non highlighted contacts are comment / suggestion authorized.

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Open Public Collaboration Process

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7. All content is subject to fact checking and correction by primary authors.
8. TBD: I'm sure more will be required as this gets out in the world.

Problem Description

Overview

See the NYT Sunday Mar 22 2020 Opinion piece for the initial request by Dr. Daniel M. Horn , an internist and Assistant Medical Director for Ambulatory Quality at Mass General:

> Opinion | How to Solve the Ventilator Shortage

He calls out three components of a solution to the serious and impending lack of ventilators to treat critical COVID-19 cases during the infection peaks that will occur across the United States and the world over the next few months.

1. A plan for ramping production akin to WWII mobilization efforts.
2. **A plan for distribution, with a cloud based system for tracking (this document's focus).**
3. A plan for highly scalable training and operation.

This article is certainly not the only characterization of the ventilator problem. Many others have described it and requested assistance for ventilators and other constrained resources, along with innovative attempts to fulfill demand:

- Ventilator Makers Race to Prevent a Possible Shortage
- Coronavirus: GM, Ford discuss with Trump admin making ventilators
- We need more ventilators. Here's what it will take to get them.
- Medtronic Has Ramped Up Ventilator Production
- The Daunting Math When It Comes To Ventilators And ICU Beds: A Look At What Places Are Strained Most For Resources
- People Are Trying to Make DIY Ventilators to Meet Coronavirus Demand

- This Italian hospital is 3D printing new respirator valves
- Specifications for simple open source mechanical ventilator Public (Google doc)
- Colombia close to having world's first open source and low-cost ventilator to 'beat Covid-19'
- Irish health officials to review 3D-printed ventilator

And in particular:

- Bill Gates on CNN talking about the need for digital system to rank needs against capacity
- NY Governor Cuomo arguing for a unified system for allocation

In the simplest terms, this is a resource allocation problem.

The resource is:

- Highly constrained (<< demand)
- Has significant manufacturing, distribution, and setup lead times before it becomes eligible for use
- Has a fixed service rate/capacity
- Has specific types, characteristics, installation / training / usage requirements, and other allocation constraints involving interdependencies between resources, facilities and actors

The demand is:

- Geographically distributed, non uniform, with high variance due to the exponential rates of change at each locality and their different phase positions on the exponential curves for their locality.
- Rapidly changing (by the hour, with huge variances), where both the actual snapshot at the current time and the projected rates of change are equally important.
- Noisy and uneven (all data is local, significantly manually tracked, from large numbers of incompatible systems, differently attributed, with highly diverse precision, coverage, and completeness).
- Non-uniform WRT prioritization policy, lacking a global prioritization regime, and local regimes for prioritization are complex, opaque, non-systematic, or completely absent.

Defining an ideal theoretical objective function for any particular allocation is ethically complicated. For example, should one maximize survival counts or life-years? These two objectives will lead to different allocation decisions (e.g. 30-year-old with 50% chance of survival vs. 95-year-old with 70% chance of survival). See here for a recent treatment in this topic.

In addition to ethical complications, there are governance issues. Any overarching global (or even federal) governing organization often has limited statutory and/or practical influence over national (regional/local) governments, so the natural state of affairs will be a complicated, diverse, overlapping, and inconsistent set of objectives active at any moment.

Complications

The following factors complicate the simplistic resource allocation model:

- **Data collection** is only partially automated, largely manual, often paper, composed of many fragmented systems and processes.

- **Authority relationships** are complex, overlapping, often opaque, and vary significantly across geographies and organizations.
- **Resource allocation policies and priorities** are a mirror of the complexity exhibited by the authority relationships.
- **Dependency relationships amongst resources and actors** further complicate allocation policy. For example, California law requires one respiratory therapist (RT) for every 4 ventilated patients - this type of requirement is generally applicable in many jurisdictions. A 2015 study found that the number of RTs was the limiting factor, not the ventilators themselves. Obviously, the number of ICU, HDU, and ward beds is a factor, as they are closely related to not only the equipment but the requirements for staffing are different for each, and depend on regulations particular to the locale.
- **The actual transfer of the resource** from provider to end use is multi-step, manually controlled, full of middlepersons, and highly variable -- again mirroring the complexity of the authority relationships and the variance amongst both suppliers and end users.

In this PRD, we propose specific solution strategies to mitigate the above complications.

Specific Vs General Solutions

Clearly this general pattern is much wider than ventilators alone, and fits many problems in the medical field (e.g. masks, protective gear, ICU beds, vaccines / drugs, blood products, donor organs, etc.), but also in the production and distribution of any critical constrained resource in many other fields.

Given the severity and timeliness of the ventilator issue, however, that subclass of the general problem is an appropriate entry point for possible solutions. Wherever possible, any system characteristic that can be generalized will be generalized, with an eye toward enabling future repurposing to arbitrary medical resources as quickly and reliably as possible. *And in particular, vaccines will likely become the next worldwide area of concern for resource allocation management systems.*

Other (Known) Efforts

Any information in this section should have zero encumbrances with respect to intellectual property claims, confidentiality, or any contractual obligations that would prevent its full public disclosure.

[US] National PPE Coalition

Overview

Players

Documents / URLs

Relationship

[US] Project N95: The National COVID-19 Medical Equipment Clearinghouse

Overview

- Targeting distribution to US only, sourcing from any country
- Coordinating with PPE manufacturers globally
- Collecting PPE needs from hospitals
- Connecting hospitals directly with suppliers for orders over 100k units
- Coordinating with governments and other large purchases to aggregate orders of fewer than 100k units
- Sharing data about needs for PPE in each state
- Ventilators in addition to PPE
- Airtable forms for:
    - Requesters
    - Suppliers
    - Government agencies (demand aggregators / distributors for > 100K unit orders)
- Data collection clearinghouse, no matching management system visible as yet, and likely largely manual, as many schema items are free form or lack detail - e.g. total beds only, not broken down between ICU, HDU, ward, and are thus are not amenable to automation.
- As of Mar 28, 2,200 requests for 290M PPE items have been received. No data on how many have been matched / transferred.

Requester Form Data Collected:

- **Contact Info**: requester email, requestor title/role, requestor name, requestor phone, purchasing contact name, purchasing contact email, purchasing contact phone
- **Request Info**: # N95 masks needed (next month), budget? (y|n), willing to prepay/deposit? (y|n), unit price max, specific certification or models, KN95 ok? (y|n), # gowns needed (next month), # invasive ventilators needed (next month), # non-invasive ventilators needed (next month), free form “anything else” field
- **Institution Info:** name, address, # beds (total, not broken down into type)

Supplier Form Data Collected:

- **Contact Info:** business name/DBA name, address, contact name, contact phone, contact email
- **Supplier Info:** company type set {manufacturer, supplier}, export license to US? [y|n], YT vid URL of product or facility, prior selling details (free form), FDA registered? [y|n], open to inspection? [y|n], payment terms [50%/50% | 100% advance | other]
- **Product Info (multiple can be defined):** type [N95, KN95, ventilator, gowns, face shield, surgical mask, surgical gloves, swabs, alcohol based sanitizer], current inventory, daily production capacity, inventory country, lead/delivery time to USA, unit cost, FDA registration (attachment), video URL of product/facility, paid for it? [y|n], proof of transit? [y|n]

Government Aggregator Form Data Collected:

- **Contact Info:** org name, contact name, contact address, contact phone, contact email
- **Budget Info:** budget? [y|n]

Players

- US Digital Response

- United States of Care

Documents / URLs

- Equipment request form
- Supplier/Manufacturer form
- Government aggregator / distributor form

Relationship

The most closely related effort we've seen. No formal contact as yet, but obvious areas of cooperation include:

- Schema sharing / coalescing
- Data sharing / federation
- Joint design on more automated matching / transfer assistance

[US] GetUsPPE.org

Overview

Players

Documents / URLs

Relationship

[US] CoProcure Covid-19 Related Contracts

Overview

Players

Documents / URLs

Relationship

Requirements Summary

General Principles

Attribution: These principles are significantly influenced by others working in the area who are not listed in the Contacts section of this document because of the proprietary nature of their work, but whose influence the authors gratefully acknowledge.

1. Coordinate as much as possible with related efforts, while balancing against the need for quick action (minimize "perfect as the enemy to good"). Try to maximize shared / embedded UI building blocks, shared schemas, and data exchange (subject to authorization and access protection).

2. Recognize that any solution will likely need to be federated (e.g. CN vs EU vs UK vs US, or even within country across provinces/states/regions or across health care systems, e.g. public vs private), and thus should be able to flex around distributed authority and data, and model complex existing organizational networks as accurately as possible.

3. Iterative development with key pilot customers (e.g. UK NHS, US HHS/FDA/FEMA/CDC, Mass General, NYC Bellevue, NYC NYU, U. Washington Medical Center).

4. Avoid Personally Identifiable Information (PII) and any HIPAA (US) triggering patient data to the greatest extent possible, other than minimal contact and authorization requirements.

5. Free (public service, not a revenue opportunity).

6. Open Data + Open Source - any embodiment of this PRD should be completely agnostic WRT hosting both data and executables on any public cloud platform or on premises data centers to assuage any fears of captivity and/or security/privacy.

7. Try to anticipate generalization to additional constrained resources (beyond the initial ventilator POC case) without sacrificing time to market.

Problem Definition & Solution Approaches

The medical resource distribution problem has the following basic components:

- Authority structure & prioritization policy definition
- Data acquisition and management WRT supply and demand
- Resource / actor dependency relationship definition
- A matching optimization WRT the defined policies and dependencies
- A transfer tracking and verification mechanism

Authority Structure & Prioritization Policy Definition

Notes:

- People allowed to set policy (i.e. who makes allocation decisions) will be a complex network.
- A special class of users will be authorized to set/change policy.
- Authorization to both change policy, and be declared authorized to change policy, will need tight control.
    - Central registry seems impossible to scale. Not clear if this is manageable at all, given the complexity of the space.
    - Some sort of distributed voting mechanism might work. E.g. as part of TODO lists, you'd be asked to vote yes or no on proposals to change policy, or to assign new policy authorized users. The scope of voters will be dependent on the policy graph (i.e. Federal, vs State/Province/Region/Trust, vs institution vs individuals)
    - A lack of vote within a specified time period (12 or 24 hours -accommodating time zone constraints), means "abstain."
    - Unanimous, majority, super majority? Probably part of the overall policy specification.

- Initially, the system should set safe and reliable defaults. E.g. when first initialized, there should be a single person who is well known and authenticated who would bootstrap policy authorization for a subset of the graph.

Resource / Actor Dependency Relationship Definition

Notes:

-

Supply & Demand Data Management

Notes:

- Lean heavily on other efforts as much as possible here.
- Leverage industry data exchange standards as much as possible (e.g. HIPAA, UDI, HIN, ONC Cures Act Rule, FHIR, TBD: others? - there must be a lot out there - need more investigation).

Matching Optimization

Notes:

- Straight up bipartite matching is a theoretical starting point, but will be not achievable in practice, given the complexity of the policy and organizational network.
- The matching function will likely be primarily a "strong suggestion" but the actual matchings will need to be accepted/authorized by responsible parties. Nobody is going to accept *"I just sent these ventilators where the tool told me to"* as a way of doing business.
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Transfer Tracking and Verification

Notes:

- Resource transfers are partially (or mostly) manual in nature. Thus the tracking & verification will require manual attention.
- Well defined states (supplier match committed, shipped, in transit states, arrived, transfer complete, etc.) will be the primary mechanism for controlling and managing transfers.
- One human owner for each state, who is pinged regularly (e.g. twice a day).
- State owner is responsible for handing off to another state/owner pair.
- Each user (owner) has a TODO list that shows current status, previous and upcoming states.
- Each transfer can be viewed in detail, including full history.
- Aggregate transfer status can also be viewed (grouped by resource type, organizations, or individuals)
- Only the resource requester that was part of the original transfer commitment can close out the transfer as completed (i.e. finally in the hands of the one that wanted it and the supplier and the relevant priority authorities agreed to transfer it to).

User Personas / Stakeholder Descriptions

Organizations

- Governments
- Medical Establishments
- Professional Associations / Accreditation
- Trade Unions
- Manufacturers
- Distribution / Logistics
- Technology Providers

Individuals

- Doctors
- RN / NP / PA / etc.
- Medical Technicians / Respiratory Therapists
- Hospital Support Staff
- Hospital Administrators
- Hospital Supply / Logistics
- Manufacturer Reps
- Distribution / Logistics Reps
- Government Agency Reps
- Medical Ethicists
- Patient Advocates

Patients / General Public

Identification / Authorization / Access Control

TBD

Ventilators

TBD

Use Case Descriptions

TBD

Success Criteria / Test Case Descriptions

TBD

Database Schema Draft

Entities and Subtypes

- **Agent**
  - Provider
  - Requester
  - Organization (prime these from public sources?)
    - Medical
      - Facility -->
      - Practice Group
      - Hospital
      -
    - Government
    - Association
  - Individual
    - Administrator (proxy for an organization)
    - Transfer authority

- **Facility** (physical location where resources can be located)
  - Supplier
    - Manufacturer
    - Remanufacturer
    - Reseller
  - Warehouse
  - Medical
    - Hospital
      - Permanent (long term fixed location with postal address and access points)

            - Temporary (e.g. Javits Convention Center, surge centers)
            - Mobile (ships, truckable units)
        - Dialysis Center
        - Ambulatory / Urgent Care Center
        - Outpatient Surgery Center
        - Nursing Home
        - Blood Bank

- **Resource**
    - Ventilators
        - Full function mechanical (endotracheal)
        - Non-invasive
            - CPAP/BiPAP
    - Oxygen
    - Other (future)

- **Need**

- **Transfer**

- **Transfer Policy**

Relationships

Notes:

- Resources have different kinds of relationships to agents: ownership, allocation authority, current user (a surge hospital may take 400 units of something, then return them to an allocation pool).
- Resources are always in some facility. Could be a warehouse or someplace they are actively being used. Every resource is physical and thus needs a location in a facility.
- Facilities could be a nested hierarchy - e.g. a large hospital would likely have its own storage, or even surge storage, of resources on hand locally. Thus the hospital could have ERs or clinics or ICUs where resources would be in use, but storage locations where resources would be idle.
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UX Mocks

Login / Authorization

TBD

Agent (Organization or Individual) Creation / Management

TBD

Facility Creation / Management

TBD

Resource Creation / Management

TBD

Need Creation / Management

TBD

Transfer Creation / Management

TBD

Transfer Policy Creation / Management

TBD

Reports / Analyses

TBD

Supply / Demand Explorer

Notes:

- Primary stakeholders: authorized allocation policy defining agents
- Overall gap, with the ability to drill down and see the gaps at finer grained authority domains
- Identification of bottleneck resources (e.g. ICU beds vs respiratory therapists vs ventilators vs oxygen vs masks/gowns)
- Tool to explore outcomes of various allocations.

Facility Explorer

Notes:

- Primary stakeholders: facility management
- Identification of current resource priorities / hot spots

Organization Explorer

Transfer Explorer

Notes:

- Primary stakeholders: logistics providers
- Bottlenecks analysis
- Transfer phase summaries (where are things at)
- Phase residence times, overall timings
- % successful and other transfer quality related thingies

Public APIs (Data Feeds & Extractions)

TBD

Platforms, Accessibility, i18n

TBD

Security & Privacy

TBD

Compliance

TBD: Need a treat a range of the most significant regulatory regimes and talk about each.

Productionization / Rollout

TBD

Possible Milestones

TBD

Design / Development / Test Regimes

TBD

Tracing / Logging

TBD

Monitoring / Alerting

TBD

Customer Support

TBD

Success Tracking / KPIs

TBD

FAQ

TBD