We require a resource manager for IT and business resources at Hypotheticorp, LLC. The kinds of reservations that are needed include:

- Software engineers and QA staff need to reserve computing resources for software development.
- Back-end IT staff need to reserve back-end server equipment for various projects across the company.
- Company-facing IT staff need to reserve loaner equipment for employees, including laptops, displays, etc.
- Managers and marketing staff need to reserve briefing rooms, catering gear, projectors, etc.

Reservation timelines may be as brief as a few hours (e.g., a projector needed for a meeting) or as long as months or years (e.g., a test server used day-to-day by an engineer).

1 Definitions

- **Resource**: An entity that can be reserved by a user.
- **Reservation**: An entry specifying that one or more resources are allocated to a user for a specified interval of time. Includes a title and description.
- **Tag**: A small piece of text used to flexibly describe a resource, e.g. “laptop”, “classroom”, “server”, etc.
- **Overlapping reservations**: Reservations which intersect in time interval. Note that two reservations where one start time equals the other’s end time are not considered overlapping.
- **Resource management permission**: A system-wide permission that grants the ability to create, delete, and manage resources.
- **Reservation management permission**: A system-wide permission that grants the ability to modify or delete any reservation.
- **User management permission**: A system-wide permission that grants the ability to create, delete, and manage users and groups.
- **View access**: A per-resource permission that grants the ability to view the resource without allowing reservation of it.
- **Reserve access**: A per-resource permission that grants the ability to reserve the resource.
- **Restricted resource**: A resource whose reservation requires special approval.
- **Resource manager**: A user authorized to grant reservations to a restricted resource.
- **Incomplete reservation**: A reservation with restricted resources still pending approval.
- **Oversubscribed resource**: A resource which has multiple incomplete, overlapping reservations.
• **Exclusively-shared resource**: A resource that can only be claimed by one reservation at a time. This is the default behavior.

• **Limited-shared resource**: A resource that can have a specified, fixed number of simultaneous reservations at a time.

• **Unlimited-shared resource**: A resource that can have an unlimited number of simultaneous reservations at a time.

2 Requirements

1. Server

   (a) Your software must have a server that supports an arbitrary number of users.

   (b) During the install/setup process, a special user named “admin” configured.

   (c) The system shall make use of the Duke NetID system to allow all users to login using their Duke credentials. The special local “admin” account remains, and retains full permissions. Support for other “local” (non-NetID) user accounts is optional.

   (d) Any stored passwords must be kept in a secure manner (e.g., salted + hashed)

   (e) All communication between the clients and server must be encrypted.

   (f) The server must maintain state in a persistent fashion.

2. Client: Basic resource tracking functionality

   (a) A user with resource management permission shall be able to create resources, which include name, description, and zero or more *tags* (see definitions above). Such users may also manage resource permissions (see below).

   (b) A user with resource management permission shall be able to modify resources in any way, as well as delete resources. The user shall be warned before deleting a resource with a current or future reservation.

   (c) A user shall be able to view the list of resources over time.

      i. Users shall be able to filter the view with a set of required and/or excluded tags. The system will make apparent the selection of tags available.

      ii. Users shall be able to set the time span being displayed. The system must be able to cope with large time spans, both in terms of performance and visual clarity.

      iii. The resulting view will show upcoming reservations on the resources in an efficient and intuitive manner, including the title and the identity of the holder of each reservation.

      iv. Resources that the user does not have permission to view shall not be visible in any way.

   (d) A user with requisite permission shall be able to reserve a resource, providing a start time/date and end time/date for the reservation. For the reservation to be granted, no other reservations must overlap the requested one except for reservations of oversubscribed restricted resources or shared resources.
(e) A user shall be able to modify the title and description of their reservation, or to reduce its time span. However, a user may not extend the time of their reservation. Instead, the system will provide a facility to allow the user to create a new reservation with the same resources as their previous reservation, subject to independent approval of its restricted resources. A user may not add resources to an existing reservation. A user with reservation management permission shall be able to modify or delete any reservation, provided that such changes do not cause a disallowed overlap in reservation.

(f) The system shall send email reminders of the start or end of upcoming reservations.

(g) Optional: Users shall be able to disable email reminders either globally or for specific reservations.

3. Groups and permissions

(a) A user with user management permission shall be able to create/delete groups, assign users to be members of groups, and set system-wide permissions for users and groups. A user can be a member of zero or more groups.

(b) The system shall track system-wide permissions which will control the ability to (1) create and manage resources (“resource management permission”), (2) create and manage groups and grant system-wide permissions (“user management permission”), and (3) manage reservations by viewing, modifying, or deleting reservations they do not own (“reservation management permission”). Such permissions can be granted to users and groups.

(c) The system shall track resource permissions for each resource. There shall be two levels of access: view access and reserve access (see definitions above). Such permissions can be granted to zero or more users and groups independently.

4. API:

(a) Every interaction described in these requirements must also be achievable via a well-documented network-based API.

(b) A simple API debugger tool must be available which allows manual testing of every API call supported in a transparent way.

5. Compound reservations

(a) In making a reservation, the user can request multiple resources at once.

(b) The user must provide a title or project name for the reservation, and may also provide a description.

6. Resource restrictions

(a) Resources may be set as restricted, meaning that reservation requires approval from a user listed as the resource's manager or someone with the reservation management permission.

(b) Resources shall have one or more managers, which are users/groups authorized to approve reservations of restricted resources. Non-restricted resources may also have managers assigned, but this confers no special ability unless the resource is later set to be restricted.
(c) A user with resource management permission shall be able to set a resource’s manager(s) as well as whether or not the resource is restricted.

(d) *Incomplete* reservations are to be shown distinctively (see definitions above).

(e) Multiple incomplete reservations may exist for the same restricted resource. This is called *oversubscription* (see definitions above), and is resolved at approval time. When a resource manager approves such a reservation, he/she shall first be warned of any competing reservations which will be necessarily cancelled as a result. Upon completing the approval, competing reservations shall automatically be cancelled. Email notifications shall be sent to affected parties.

(f) If a reservation begins while still incomplete, it is cancelled and its resources are freed for others to reserve. A notification email is sent if this occurs. Before this occurs, warning emails are sent cautioning the user that their reservation will not be honored without the missing approvals.

(g) If an approval is denied, the entire reservation is cancelled, and the user is notified via email.

7. Resource sharing

(a) Resources shall have a configurable *level of sharing*, which may be *exclusive* (only one reservation may claim the resource at a time – the default behavior), *limited* (allowing a fixed quantity of simultaneous reservations), or *unlimited* (allowing any number of simultaneous reservations). The quantity of simultaneous reservations for *limited* resources is set on a per-resource basis. These attributes are set by a user with resource management permission.

(b) These attributes are entirely separate from the *restricted* feature. The two features interact as follows:
   
i. The case of exclusively-shared restricted resources is described in item 6e.
   
ii. In the case of limited-shared restricted resources with limit $n$, the handling is similar to exclusive resources: resources may be oversubscribed, and the oversubscription is resolved by the manager at approval time. The only difference is that implicit cancellation of competing reservations occurs when the $n$-th reservation that conflicts at a given time is approved.
   
iii. In the case of unlimited-shared restricted resources, oversubscription is impossible. However, while many reservations may claim it at once, only those reservations that are approved will be allowed to start.

(c) A user may not be awarded a reservation that violates these limitations.

8. Resource hierarchy

(a) Resources shall exist in a hierarchy.

(b) Reserving a parent automatically reserves its children, though reservations shall still respect the sharing and restriction settings of all involved resources.

(c) The ability for resource managers to approve reservations of restricted resources functions on a per-resource basis and is unaffected by the hierarchy feature. A user being a manager of a parent resource confers no special ability with respect to child resources.
(d) The resource hierarchy shall be displayed in an intuitive manner to users creating reservations.

(e) Users with appropriate resource-management permission shall be able to modify and arrange the hierarchical relationships of resources in an intuitive manner.