Problem description

The problem considers selection of an optimal set of video representations for an adaptive network streaming application [1]. Multiple streaming websites, such as YouTube, Vimeo, etc., allow its users to request different videos in multiple resolutions and bitrates. The videos are usually delivered over a Content Delivery Network (CDN), which stores several different representations (in terms of resolution and bitrate) of videos. The storage space in the CDN is limited, therefore only a fixed number of these representations can be made available. Vendors like Apple, Microsoft and Netflix give recommendations how many different representations of a video should be stored and what bitrate and resolutions they should have. However, blind application of these recommendations might lead to a situation when unneeded versions of a video or other content is stored in the CDN. For instance, movies and short funny videos are often streamed to different devices (TVs vs. smartphones). Therefore, having high-resolution version of funny movies is not as important as of movies. The benchmark problem is derived from a need of CDNs to determine the set of representations of a particular content such that the satisfaction of an average user is maximized.

Each of the problem instances provides:

- $Video$ – a set of videos: $\{video, sport, documentary, cartoon\}$
- $Resolition$ – a set of available resolutions: $\{224,360,720,1080\}$
- $Bitrate$ – a set of possible bitrates which ranges from 150kbs to 8650kbs with a step of 50
- $User$ – a set of users, where each user
  - requests a video of a particular type in some resolution
  - has a connection with a fixed bandwidth
- the maximum capacity of the network (5000 KB/s per user)
- satisfaction function $f: Video \times Resolution \times Bitrate \rightarrow N$

The goal is to assign a video representation, i.e. a tuple (video type, resolution, bitrate), to each user such that:

- the number of assigned representations is not greater than the maximum number of representations (the storage in the CDN is limited)
  - think of limited amount of storage space available on servers
  - they have a resolution + bitrate and a resulting satisfaction value
- 95 % of these users must be served as requested, i.e. each such user must get a representation assigned that corresponds to the requested video and resolution
  - bitrate of representation <= bandwidth of user
- the total user satisfaction is maximized

$$totalSat = \sum_{r \in Assign} f(r)$$

where $Assign$ is a set of tuples $(video, resolution, bitrate)$ that were assigned to users.

[1] Laura Toni, Ramon Aparicio-Pardo, Gwendal Simon, Alberto Blanc, and Pascal Frossard. "Optimal set of video representations in adaptive streaming." In *Proceedings of the 5th ACM Multimedia Systems Conference*, pp. 271-282. ACM, 2014.

Predicates

- Input: `user/6, f/4`
- Output: `assign/5`

Input format

For simplicity, we consider only videos, resolution and bitrates that were requested by users and to not provide the whole catalog. One instance consists of a set of users encoded as facts over `user/6` predicate. For example:

```
user(0, "Documentary", 360, 202, 770461083, 200).
user(USER_ID, VIDEO_TYPE, RESOLUTION, BANDWIDTH, MAX_SAT, MAX_BITRATE).
```

- `USER_ID`: unique ID of a user
- `VIDEO_TYPE`: video type requested by the user
- `RESOLUTION`: resolution requested by the user
- `BANDWIDTH`: available network bandwidth of the user
- `MAX_SAT`: maximum achievable satisfaction value for this user
- `MAX_BIRATE`: highest possible bitrate available for this user

Similarly, the satisfaction function was precomputed for all possible values that might be required to compute the total satisfaction of users with their assignments. The satisfaction function is given by a set of facts over `f/4`.

For example:

```
f("Documentary", 360, 200, 770461083).
f(VIDEO_TYPE, RESOLUTION, BITRATE, SAT_VALUE).
```

- `VIDEO_TYPE`: video type of the representation
- `RESOLUTION`: resolution of the representation
- `BITRATE`: bitrate of the resolutions
- `SAT_VALUE`: resulting satisfaction value when this representation is assigned to user

Constants:

```
#const global_capacity = 100000.
```

Global capacity of the network that has not to be exceeded by the sum of the assigned bitrates.

```
#const fraction_user = 19.
```

Number of users that have to be assigned to a representation.

```
#const max_representations = 19.
```

Maximum number of different representations assigned to users.

Output Format

The solution must by encoded by the predicate: `assign/5`.

For example:

```
assign(0, "Documentary", 360, 220, 770461083).
assign(USER_ID, VIDEO_TYPE, RESOLUTION, BITRATE,SAT_VALUE).
```

- `USER_ID`: user ID
- `VIDEO_TYPE`: assigned/requested video type
- `RESOLUTION`: assigned/requested resolution
- `BITRATE`: bitrate of the assigned representation
- `SAT_VALUE`: satisfaction value of the assigned representation