CPTV - Generating Personalized TV Schedules

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Typical Applications of Constraint Programming

- Industrial Scheduling
- Configuration
- Personnel Planning
- Transport
- Network Optimization
Personal CP Applications

- Not a lot of applications for individual use
- People don’t have NP-hard problems?
- Some advisors, recommenders based on CP
  - ECRC: The Munich Rent Advisor, (Fruewirth et al, 1994)
  - 4C: Talking Shop (Little et al, 2008)
- Sudoku?
Important: Proof of Concept

- This is not about the model
- This is not about the constraint engine
- This is about the application
- Funded to show how such a system would work
- Explore functionality, data feeds, etc
- No beautiful interfaces, just get it to work
Some Facts about TV

- In Ireland, 75% of households have satellite or cable (Source: Comreg, 2009)
- Easy to get 200+ channels
- Average TV viewing time
  - US, per household, in 2008: 8 Hr. 21 Min/day, (Source: Nielsen, 2009)
  - UK, per person: 28 Hr/week (van den Broek, 2002)
- 95% of TIVO TV watching is live, not recorded or time-shifted (Bronnenberg et al, 2010)
- UK Total TV market 10B£ (Source: Ofcom, 2006)
A Requirement for Personalized TV

- 200 channels, and I don’t know what to watch!
- Record & watch is not the defining paradigm
  - Some programs you have to watch live (sports)
  - Others you can time-shift within a day (news)
  - Others you can watch anytime (movies)
  - Some programs you have to watch in sequence, others not
- DVR is not an infinite resource
- Don’t record what you won’t watch
- There is a life beyond TV
Existing Work

- 1995-2002: Many papers on TV recommenders
- Mainly collaborative recommenders
- Quite limited acceptance
- No concept of time/scheduling
Current Solutions

- Nearly always grid based (just like printed program guides)
- This works for 4 channels, not for 200
- Even more so when running on a mobile phone
- Settop boxes:
  - Record complete series
  - Program from mobile
  - LRU replacement strategy
Typical Grid View

<table>
<thead>
<tr>
<th>Channel</th>
<th>Time</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>12:00</td>
<td>Diagnosis Murder: 35 Millimetre Murder</td>
</tr>
<tr>
<td>All</td>
<td>12:15</td>
<td>Murder, She Wrote: If the Frame Fits</td>
</tr>
<tr>
<td>All</td>
<td>12:30</td>
<td>Diagnosis Murder: 35 Millimetre Murder</td>
</tr>
<tr>
<td>At The Races</td>
<td>12:30</td>
<td>Racing Live</td>
</tr>
<tr>
<td>BBC One Generic</td>
<td>12:30</td>
<td>BBC News at One</td>
</tr>
<tr>
<td>BBC Two Generic</td>
<td>12:30</td>
<td>The Daily Politics</td>
</tr>
<tr>
<td>Boomerang</td>
<td>12:30</td>
<td>Bugs and Daffy</td>
</tr>
<tr>
<td>Boomerang +1</td>
<td>12:30</td>
<td>Tom and Jerry</td>
</tr>
<tr>
<td>Bravo</td>
<td>12:30</td>
<td>Dog the Bounty Hound</td>
</tr>
<tr>
<td>Bravo</td>
<td>12:30</td>
<td>Most Shocking Under the Influence</td>
</tr>
<tr>
<td>Bravo 2</td>
<td>12:30</td>
<td>World's Most Amazing Videos</td>
</tr>
<tr>
<td>British Eurosport</td>
<td>12:30</td>
<td>FIFA Under-17 World Cup</td>
</tr>
<tr>
<td>British Eurosport 2</td>
<td>12:30</td>
<td>Eurosport2 News</td>
</tr>
<tr>
<td>CNBC</td>
<td>12:30</td>
<td>US CNBC Squawk Box</td>
</tr>
<tr>
<td>Challenge</td>
<td>12:30</td>
<td>Challenge</td>
</tr>
<tr>
<td>Challenge +1</td>
<td>12:30</td>
<td>Wipeout</td>
</tr>
<tr>
<td>Challenge</td>
<td>13:00</td>
<td>Challenge</td>
</tr>
<tr>
<td>Channel 4</td>
<td>13:00</td>
<td>News at Noon</td>
</tr>
<tr>
<td>Comedy Central</td>
<td>13:00</td>
<td>Scrubs: My Best F...</td>
</tr>
<tr>
<td>Comedy Central +1</td>
<td>13:00</td>
<td>The King of Quee...</td>
</tr>
<tr>
<td>Comedy Central Extra</td>
<td>13:00</td>
<td>Everybody Loves...</td>
</tr>
<tr>
<td>Comedy Central Bitr</td>
<td>13:00</td>
<td>Everybody Loves...</td>
</tr>
<tr>
<td>Dave</td>
<td>13:00</td>
<td>Top Gear</td>
</tr>
<tr>
<td>Dave ja vu</td>
<td>13:00</td>
<td>Stephen Fry in America: New World</td>
</tr>
<tr>
<td>Discovery Home and...</td>
<td>13:00</td>
<td>Brit Camp II</td>
</tr>
<tr>
<td>Discovery Home and...</td>
<td>13:00</td>
<td>Jon and Kate Plus...</td>
</tr>
<tr>
<td>Discovery Real Time</td>
<td>13:00</td>
<td>A Piece by the Sea: Paola Bay</td>
</tr>
<tr>
<td>Discovery Real Time</td>
<td>13:00</td>
<td>Come Dine with Me</td>
</tr>
<tr>
<td>Discovery Shed</td>
<td>13:00</td>
<td>Smith and Sweet...</td>
</tr>
<tr>
<td>Discovery Travel and...</td>
<td>13:00</td>
<td>Superhomes: Pas...</td>
</tr>
<tr>
<td>Discovery Travel and...</td>
<td>13:00</td>
<td>No Going Back: A...</td>
</tr>
<tr>
<td>Helmut Simonis</td>
<td></td>
<td>CPTV</td>
</tr>
</tbody>
</table>
In the Beginning - Data

- What can we do with existing/accessible data
- Not what data would we like
- Small project, limited resources
- Most data is in wrong/unstructured format
- We can’t afford to enter data by hand
- We initially don’t have large user base to provide data for us
Data Sources

- XMLTV - TV Program data
- Lots of information about shows and movies
  - Wikipedia
  - IMDB, Rotten Tomatoes, Metacritic: Movie reviews
  - Epguide: Episode names, sequence
  - TVTropes: Deep content based discussion of TV, movies, anime, comics
- Personal Calendars: iCal
- Providers: Channel lists and packages
<programme start="20091128220000 +0000" stop="20091129000000 +0000" channel="zonethriller.tv">
  <title>Don’t Look Back</title>
  <desc lang="en">Bleak drama about an alcoholic drug addict who hopes his fortunes have changed when he finds a stash of money. But it transpires that the cash belongs to the Mob, and the man is forced into hiding in his hometown where his friends are drawn into his dilemma.</desc>
  <credits>
    <director>Geoff Murphy</director>
    <actor>Eric Stoltz</actor>
    <actor>John Corbett</actor>
    <actor>Josh Hamilton</actor>
    <actor>Annabeth Gish</actor>
    <actor>Billy Bob Thornton</actor>
    <actor>Dwight Yoakam</actor>
  </credits>
  <date>1996</date>
  <category lang="en">Film</category>
</programme>
Architecture

- **Motivation**
- **Overview**
- **Scheduler**
- **Conclusions**

**Architecture Diagram**:

- **Data Feed**
  - **Known Programs** → **Program Selector** → **Rules**
  - **Recommender** → **Interesting Programs**
  - **Back Catalog** → **Scheduler**

**Scheduler Subdivisions**:

- **Recording Schedule**
  - **DVR/PC/Settop box**
- **Watch Schedule**
  - **Calendar/Mobile**
Program Selector

- Rule based program selection
- Rules entered by user
- Rules entered manually or defined by similarity
- Attributes/Relations
  - Title, category, cast, season/year, channel, keyword, time
  - is, in, not in, contains, before, after
- Prolog search engine
### Set of Rules for User

<table>
<thead>
<tr>
<th>Enabled</th>
<th>Title</th>
<th>Priority</th>
<th>Per Day</th>
<th>Per 2 Days</th>
<th>Per Week</th>
<th>Time</th>
<th>Place</th>
<th>Mood</th>
<th>Condition(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>true</td>
<td>Bones</td>
<td>Very Keen</td>
<td>0 - 1</td>
<td>0 - 1</td>
<td>0 - 5</td>
<td>no</td>
<td>yes</td>
<td>any</td>
<td>title is Bones</td>
</tr>
<tr>
<td>true</td>
<td>BBC News</td>
<td>Must Watch</td>
<td>0 - 1</td>
<td>0 - 10</td>
<td>0 - 5</td>
<td>shift</td>
<td>yes</td>
<td>any</td>
<td>title starts with BBC News, start is 2200</td>
</tr>
<tr>
<td>true</td>
<td>Celtic Connections</td>
<td>Quite Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>title is Celtic Connections</td>
</tr>
<tr>
<td>true</td>
<td>Fleash Cheers</td>
<td>Quite Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>title is Fleash Cheers</td>
</tr>
<tr>
<td>true</td>
<td>Battlesstar Galactica</td>
<td>Very Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>title is Battlesstar Galactica</td>
</tr>
<tr>
<td>true</td>
<td>Joan of Arcadia</td>
<td>Quite Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>title is Joan of Arcadia</td>
</tr>
<tr>
<td>true</td>
<td>Monk</td>
<td>Very Keen</td>
<td>0 - 1</td>
<td>0 - 1</td>
<td>0 - 5</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>title is Monk</td>
</tr>
<tr>
<td>true</td>
<td>Fayle's War</td>
<td>Quite Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>title is Fayle's War</td>
</tr>
<tr>
<td>true</td>
<td>Megestructures</td>
<td>Keen</td>
<td>0 - 1</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>title is Megestructures</td>
</tr>
<tr>
<td>true</td>
<td>Coronation Street</td>
<td>Interested</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>title is Coronation Street</td>
</tr>
<tr>
<td>true</td>
<td>Doctor Who</td>
<td>Very Keen</td>
<td>0 - 1</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>title is Doctor Who</td>
</tr>
<tr>
<td>true</td>
<td>The Simpsons</td>
<td>Interested</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>title is The Simpsons</td>
</tr>
<tr>
<td>true</td>
<td>QI</td>
<td>Very Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>title is QI, channel in [BBC2, BBC4]</td>
</tr>
<tr>
<td>true</td>
<td>Russian Revolution</td>
<td>Very Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>category in [Documentary], keyword in [History, Russia, Revolution, Lenin, Stalin, Soviet]</td>
</tr>
<tr>
<td>true</td>
<td>Titanic</td>
<td>Very Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>no</td>
<td>any</td>
<td>keyword in [Titanic]</td>
</tr>
<tr>
<td>true</td>
<td>Wind Energy</td>
<td>Very Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>keyword in [Wind Energy, Wind Turbine, Alternative Energy]</td>
</tr>
<tr>
<td>true</td>
<td>Classical Music</td>
<td>Quite Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>no</td>
<td>any</td>
<td>category is Music and Arts, keyword in [Classical Music, Bach, Beethoven, Mozart, Handel]</td>
</tr>
<tr>
<td>true</td>
<td>Champions League</td>
<td>Must Watch</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>no</td>
<td>yes</td>
<td>Sport</td>
<td>any</td>
<td>title contains Champions League Live</td>
</tr>
<tr>
<td>true</td>
<td>Time Team</td>
<td>Quite Keen</td>
<td>0 - 1</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>yes</td>
<td>yes</td>
<td>any</td>
<td>title contains Time Team</td>
</tr>
<tr>
<td>true</td>
<td>John Ford</td>
<td>Must Watch</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>no</td>
<td>any</td>
<td>director is John Ford</td>
</tr>
<tr>
<td>true</td>
<td>Howard Hawks</td>
<td>Must Watch</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>no</td>
<td>any</td>
<td>director is Howard Hawks</td>
</tr>
<tr>
<td>true</td>
<td>Kate Reckinsale</td>
<td>Very Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>no</td>
<td>any</td>
<td>actor is Kate Reckinsale</td>
</tr>
<tr>
<td>true</td>
<td>****</td>
<td>Quite Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>no</td>
<td>any</td>
<td>star_rating is 3/5</td>
</tr>
<tr>
<td>true</td>
<td>****</td>
<td>Keen</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>no</td>
<td>any</td>
<td>star_rating is 4/5</td>
</tr>
<tr>
<td>true</td>
<td>****</td>
<td>The Mentalist</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>no</td>
<td>any</td>
<td>title is The Mentalist</td>
</tr>
<tr>
<td>true</td>
<td>****</td>
<td>The Mentalist</td>
<td>0 - 1</td>
<td>0 - 2</td>
<td>0 - 5</td>
<td>yes</td>
<td>no</td>
<td>any</td>
<td>title contains 6.5</td>
</tr>
</tbody>
</table>
### Result: Interesting Programs

<table>
<thead>
<tr>
<th>Day</th>
<th>Start</th>
<th>End</th>
<th>Scheduled</th>
<th>Title</th>
<th>Year</th>
<th>Category</th>
<th>Status</th>
<th>Channel</th>
<th>Value</th>
<th>Why</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun 15/11</td>
<td>14:20</td>
<td>16:10</td>
<td>--/--/---</td>
<td>Battlestar Galactica</td>
<td></td>
<td>Drama</td>
<td>dv</td>
<td>Sci Fi +1</td>
<td>1000</td>
<td>Battlestar Galactica</td>
</tr>
<tr>
<td>15:19</td>
<td>17:00</td>
<td>--/--/---</td>
<td>Battlestar Galactica</td>
<td></td>
<td>Drama</td>
<td>dv</td>
<td>Sci Fi</td>
<td>1000</td>
<td>Battlestar Galactica</td>
<td></td>
</tr>
</tbody>
</table>

---

Helmut Simonis  
CPTV
Two different systems
  - One for movies
  - The other for TV shows
Both are content based recommenders
No start-up problem
Lots of content description available
Recommender Systems

- Collaborative
  - Users, who are similar to you, also like this
  - Requires large user base to be meaningful
  - Works well with positive and negative examples

- Content based
  - These items share characteristics with the items you like
  - Requires “mineable” description of content
  - Categories, tags and keywords can be useful
### Top Recommendations for this Week

<table>
<thead>
<tr>
<th>Title</th>
<th>Year</th>
<th>Entries</th>
<th>Rating</th>
<th>Stars</th>
<th>RT</th>
<th>Director</th>
<th>Cast</th>
<th>Repeat</th>
<th>Prem</th>
<th>Score</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pirates of the Caribbean: The Curse</td>
<td>2003</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>Gore Verbinski</td>
<td>Johnny Depp, Keira Knightley</td>
<td>no</td>
<td>no</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>of the Black Pearl</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Mummy</td>
<td>1999</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td>Stephen Sommers</td>
<td>Brendan Fraser, John Hannah</td>
<td>no</td>
<td>no</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>Under Siege</td>
<td>1992</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>Andrew Davis</td>
<td>Steven Seagal, Tommy Lee</td>
<td>no</td>
<td></td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>John</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Jones</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blade Runner</td>
<td>1982</td>
<td>1</td>
<td>15</td>
<td>6</td>
<td></td>
<td>Ridley Scott</td>
<td>Harrison Ford, Rutger</td>
<td>no</td>
<td>no</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hasse</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Die Hard</td>
<td>1988</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>John McTiernan</td>
<td>Bruce Willis, Alan Rickman</td>
<td>no</td>
<td></td>
<td>33</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Miss Congeniality</td>
<td>2000</td>
<td>2</td>
<td>12</td>
<td>6</td>
<td></td>
<td>Donald Petrie</td>
<td>Sandra Bullock, Michael</td>
<td>no</td>
<td>no</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Caine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Rays</td>
<td>1995</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>Michael Bay</td>
<td>Martin Lawrence, Will Smith</td>
<td>no</td>
<td></td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Twister</td>
<td>1990</td>
<td>2</td>
<td>15</td>
<td></td>
<td></td>
<td>Jan De Bont</td>
<td>Bill Paxton, Helen Hunt</td>
<td>no</td>
<td>no</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Demolition Man</td>
<td>1993</td>
<td>4</td>
<td>15</td>
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Outline

1. Motivation
2. Overview
3. Scheduler
4. Conclusions
Constraints

- You can only watch one program at a time
- Depending on your tuner, you can not record more than \( n \) programs at a time
- We assume that you watch programs completely
- From the description and rules we know which programs must we watched
  - Live
  - Time shifted on same day
  - Can be watched anytime
- If programs are repeated, you should only watch them once
Viewing Preferences

- Programs are classified by the rules
- Based on categories, not numerical values
  - Must watch
  - Very keen
  - Quite keen
  - Keen
  - Interested
  - Not interested
- Try to maximize each category in turn
Best Quality?

- HD/SD quality
- Surround sound
- Some channels have few/many ad breaks, others none
- Some information in XMLTV data
- Look at program duration
- Display device available
More Constraints

- You can only watch TV in your “TV time windows” (based on calendar availability rules)
- If you have another event in the calendar, then don’t schedule TV for that time
- If you are away from home, then you may/may not be able to watch TV
- You may not want to watch movies remotely on a mobile phone, but perhaps your home sport news
Viewing Windows

![Calendar Image]

- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday
- Sunday

- Click to enable Instant Search

- 24 - 30 May 2010

- 13:00
- 14:00
- 15:00
- 16:00
- 17:00
- 18:00
- 19:00
- 20:00
- 21:00
- 22:00
- 23:00

- Click to add appoints

- Home

- Home

- Home

- Home
Even More Constraints

- There may be limits on how many programs of the same show you want to watch
- “The Simpsons” marathon, anyone?
- There may be limits on how many shows of a particular category you want to watch on a day
  - on two consecutive days
  - within a week
Final Constraints

- Some series must be watched in sequence, others don’t need to.
- This rarely matters for repeated shows.
- If you start a series, then you want to watch all episodes, or none.
  - Don’t skip every second episode of “Lost”.
- For some series, only schedule the current season (new programs).
You can stream some shows from the Internet, without recording

If this is legal (e.g. BBC Player), there are constraints on the time window

Program will be available after first transmission, and then for 7, 14, 28 days
Family Constraints

- Are you fighting for the remote all the time?
- Many resource constraints due to multiple viewers
- Not handled so far
Modelling this problem with Constraints

- Finite domain model
- MIP model for live TV only
- Hybrid MIP/FD
Finite Domain Constraint Programming

- Problems are expressed by variables and constraints
- Variables range over possible domain
- Constraints restrict feasible values for variables
- Many different types of constraints are known
- Propagation removes values which can not be in solution
- Coupled with search to find solution
Finite Domain Model

- Each selected program is a potential task
- Tasks must be scheduled on resources
  - Disjunctive resources (TV)
  - Cumulative resources (DVR)
  - Alternative resources (DVR/PC)
- Viewing windows handled by
  - dummy tasks
  - calendar constraint
- Producer/Consumer constraints for storage
- Lots of temporal constraints
Search

- Incomplete search
  - Credit based search
  - With time limit
- Heuristic: Try to schedule valuable programs first
Problems with Model

- Most selected programs can not be scheduled
- This is modelled with
  - Dummy value
  - Very large horizon, cut off after two weeks
- Good reasoning requires special versions of resource constraints
What about Cost?

- We don’t want just any solution
- Solution should “maximize” our enjoyment
- Maximize an objective function?
- Sum of values for each scheduled program
- Very weak reasoning on this cost
Alternative: Solve a simpler problem

- Consider you can not record programs
- All programs must be watched live
- Can be modelled with MIP
MIP Model for Restricted Problem

- For each selected program define a 0/1 variable $x_i$
- $x_i$ decides if program $i$ is scheduled or not
- If program is scheduled, its time is fixed
Constraints in MIP Model

- Watch only one program at a time
  \[ \forall t : \sum_{i_{\text{overlap}}} x_i \leq 1 \]
- Don’t watch repeated programs twice
  \[ \forall p : \sum_{i_{\text{repeats}}} x_i \leq 1 \]
- Only \( k \) movies on a day/in a week
Maximizing Enjoyment

- Objective Function
- $\max \sum_i w_i x_i$
- Handled very well by MIP solver
Problems with MIP Model

- Some temporal constraints are tedious (minor)
- Very hard to extend to record & watch
- Variables $x_{it}$ program $i$ is watched at time $t$
- Too many time points, model explodes
Solution: Hybrid Model

- Combine the best features of both approaches
- Avoid weaknesses by exploiting strength of methods
- First Step: Allocation to time periods
- Second Step: Detailed sequencing
Step 1: Allocation to Time Periods

- MIP Model
- 0/1 variable $x_{ip}$ tells if program $i$ is scheduled in period $p$
- Increases number of variables only by small factor (14 days horizon)
- Keep objective function
- Handle capacity of each period by multiple knapsack constraints
  \[ \forall p : \sum_i d_i x_{ip} \leq c_p \]
- Capacity expressed as time, but also possible for categories, etc
- Use rounding of coefficients to decrease complexity
- Don’t fix recording schedule, but post redundant constraint
Step 2: Detailed Sequencing

- Finite domains
- Only model scheduled programs, huge reduction in variables
- Recording constraints given by choosing between fixed transmission times
- Temporal constraints between recording and watching tasks
- Usual resource constraints
- Allow relaxation of time window end to avoid infeasible second phase
Schedule in Google Calendar
Variant: Suggest alternatives

- Allow two programs to be watched at any time
- Give user more flexibility
- Only requires capacity change in both models
Alternative Suggestions

Image of a calendar showing scheduled events for the week of 23rd to 29th November 2009.
Outline

1. Motivation
2. Overview
3. Scheduler
4. Conclusions
Resources Needed

- Complete application written in ECLiPSe
- Linked to Apache webserver
- Heavily reliant on XML parser, DCG and other tools
- Finite domain and MIP solver in ECLiPSe
- Code size: < 20k lines
- Development effort: 3-4 months
It’s all about the Data

- Data availability defines functionality
- Most data is intended for humans, not constraint programs
- Wiki data is the worst, crazy humans!
- XML data feeds sometimes exist, but may be expensive
TVTropes.org: Wiki Madness, but Good Classifiers

- **Work Com**
- **Worth It**: Lutz, after pissing everyone off by choosing Subway when it's his turn to pick where the staff eats.
- **Writer Revolt**: When forced to write an environmental-themed episode for NBC's Green Week, the writers instead wrote a brutal satire of NBC's own environmental greenwashing, and then did it again the following year, and brought back former VPOTUS AL Gore to "re-cycle" a joke. Also the one episode broadcast during the WGA writer's strike in season 2 (the un-named episode 210) has no writers in it, implying that they are on strike. During the Writer's Strike, the cast of *30 Rock* performed a live episode on-stage off-Broadway to raise money for the strikers.
- **You Look Familiar** (Rachel Dratch in the first season)
- **Your Costume Needs Work**: Jenna met her boyfriend Paul at a Jenna Maroney impersonator contest. He came in first place; she came in fourth.
- **Your Mom**: A Most Triumphant Example in "Floyd." After an participating in a Prank war, Frank, Twofer, and Lutz, are able to find Jack's *Weaksauce Weakness* of having someone say "Twig and Plums" which makes him leave the room. To get back at them, Jack send them a tape stating that he seduced Frank's mom and threatens to do the same to Twofer's and Lutz's. Danny (who has been helping Jack) pops his head in front of the Camera stating "Hi Frank! Your mom's a hugger."

And subverts/parodies/lampshades or otherwise plays with:

- **And Knowing Is Half The Battle**: Tracy's public service message about the importance of Japanese sex dolls.
- **Ascended Fanboy** (Kenneth)
- **Author Tract** (an obvious parody of *Studio 60* in an early episode, ending with Lemon confusing herself and saying that she needs to read more)
- **Corrupt Corporate Executive**: Jack, though classist and greedy, is arguably the most sympathetic character on the show.
- **Double Standard**: (Lampshaded: "Women are allowed to get angrier over the double standard than men are!")
- **Fake American** (subverted; a British actress plays an American pretending to be a Brit and only has to do one line with an American accent)
- **Executive Meddling** (portrayed on the show) (Also happened in *Real Life* - in Fey's original treatment the *Show Within A Show* was a newscast; they told her to go ahead and make it a sketch comedy because that's what she knows)
- **Gilligan Cut**: Lampshaded by Pete when Tracy insists that he couldn't possibly get in trouble while going on a historical walking tour.
What makes a nice TV evening?

- Sequencing of programs
- Compare: Automatic Generation of Music Programs (Pachet and Roy, 1999)
- React to user’s mood
- Can we learn from observing actual behaviour?
  - Rules
  - Programme sequencing
- Micro-controller based logging tool?
Do people really watch TV like this?

- Modelling zapping
- Watching parts of programs only
- TV as background noise
Multi-User Version

- Viewing schedule for groups
- Resource conflicts for recording/storing
Already deals with SkyPlayer (Movie on Demand)

Attempted IPTV lock-in

Who will provide program data for the Internet
Late Breaking News: Google TV

- Announced yesterday
- Finds TV shows in TV listings and on the Web
- Hardware+software: Partnered with Sony
- Still needs a scheduler
Summary

- **Personalized TV Schedules**
- **A real AI problem**
  - Classical AI personal assistant
  - Understand web pages intended for humans
  - Rule based program selection
  - Content based recommender systems
  - Understand/create calendar data
  - Interact with human