SFU

Complex Systems Modelling Group

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Math 800

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Two distinct models of the criminal justice system in B.C.

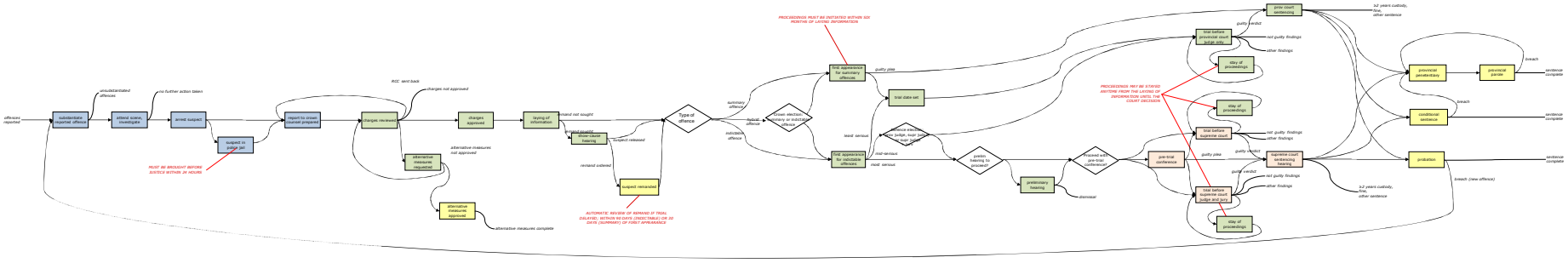
Models in practice

The project

- Models for the Ministry of the Attorney General and the Ministry of Public Safety and Solicitor General in B.C.
- Models are developed by the CSMG and the ministries.
- Ongoing since 2007
- About 26 collaborators

The Criminal Justice System of B.C.

A high level model



The Criminal Justice System of B.C.

- Many actors
  - Police
  - Crown
  - Several courts
  - Corrections
- Many dependencies within and between parts
  - Hearings versus people in remand
  - Sentencing outcomes and time in custody
- Many units of interests
  - People
  - Charges
  - Cases
  - Time at stages

It is HUGE and COMPLEX

The Criminal Justice System of B.C.

What is the purpose of a model of the CJS?

- Forecast impacts from changes to or from within the system
  - Decision making
  - Legislative changes
  - Resource demand or utilization
  - Strategic planning

Two models

General Criminal Justice System model

- Connects Police, Crown, courts and corrections at a high level
- Focuses on how a change in one part of the system affects the others
- System dynamics model

Remand credit model

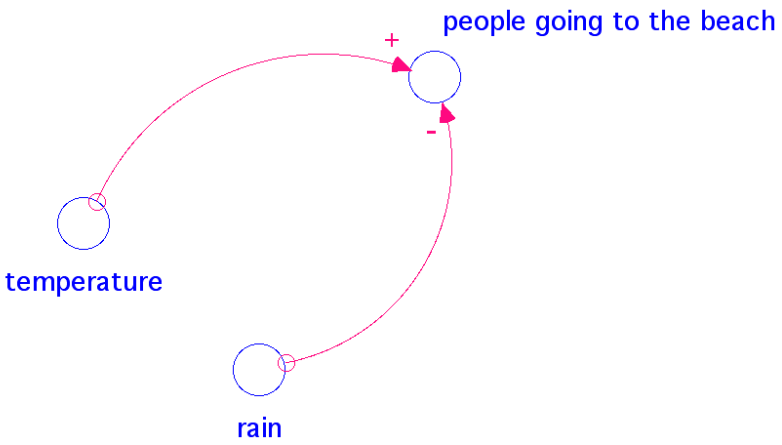
- Connects courts processes and custodial corrections
- Focuses on the impact of a specific bill on Custodial corrections
- Queue network model

The general Criminal Justice System model

A system dynamics adventure

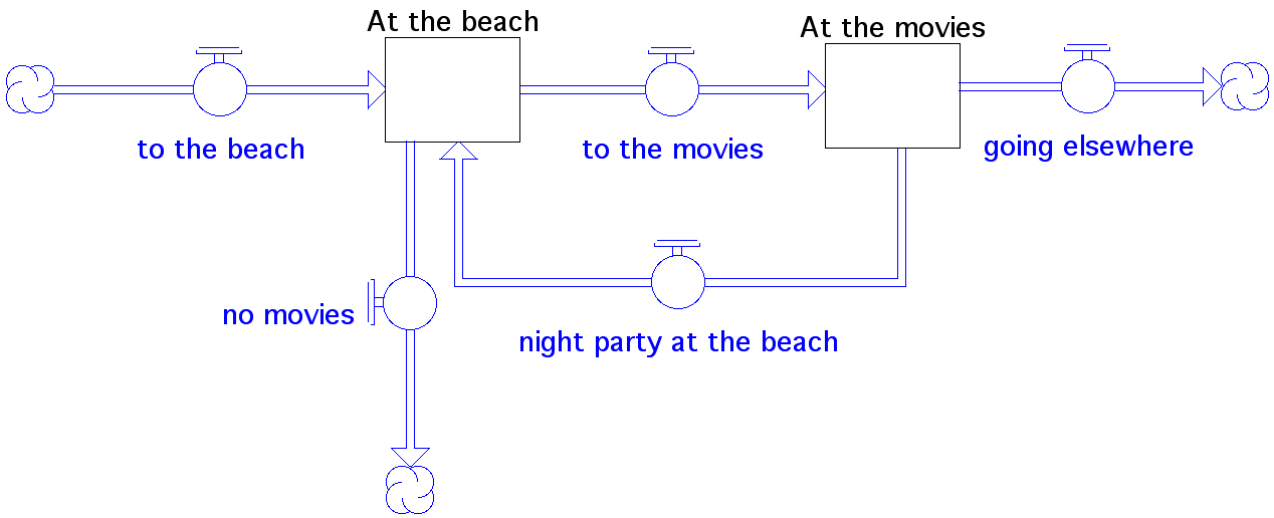
System dynamics model characteristics I

- System thinking
  - Method of thought as opposed to a modelling technique.
  - System as a whole
  - Describe the interactions between parts qualitatively
  - Influence diagram



System dynamics model characteristics II

- Stocks
  - Values at specific dates
  - ``Accumulation points'' of entities
- Flows
  - Movement of undistinguishable entities
  - Determine volume changes to a stock
- Volumes at main stage



System dynamics model characteristics III

- Qualitative
  - Conceptual design of processes
  - Expert knowledge
- Quantitative
  - Equations based on actual data to govern the stocks
    - May rely on time
    - May rely on the state of the system or stocks
  - Predictions of the system's behaviour
  - Mainly presents averages
- Continuous
- Relatively data friendly

The general CJS model design

- Major stages in each sub-system
- Bottlenecks
- Points where changes are imposed, expected or explored
- Incorporate expert knowledge
- Incorporate data from different sources
- Crime types
- Regions
- Many monthly time series data

Equations and estimation tools

- For model inputs monthly data series forecasts
  - State space method with exponential smoothing
  - Seasonality
  - Time trend
  - No linear regressions
- Linear regressions
  - Within limits
- Optimization techniques
  - Simultaneous stock and flow estimation of linear equations such as the Nelder-Mead method
  - Beware of the initial value
- Out of sample testing
  - Validation

Once satisfied use it

- General model demo

Remand credit model

A queue network treasure

Bill C-25

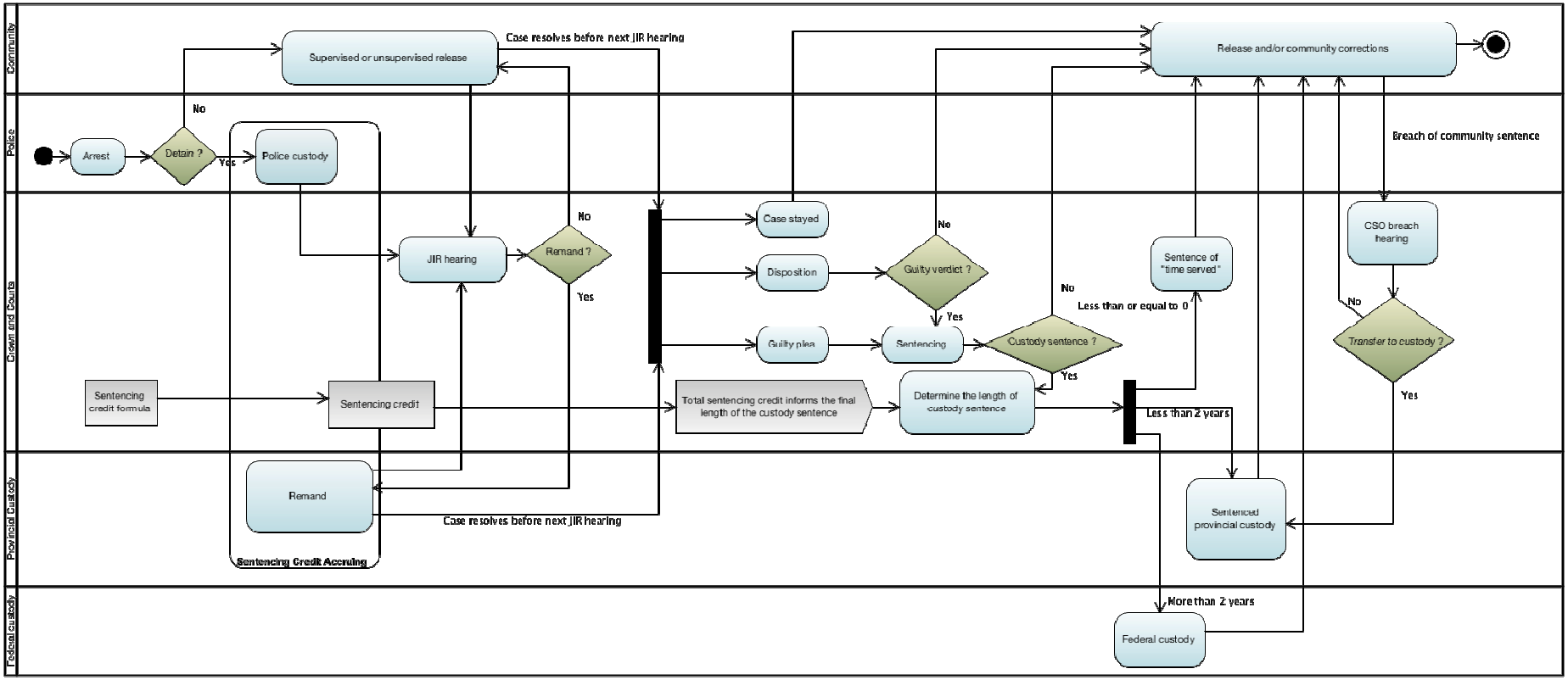
Bill C-25: Truth in Sentencing Act came into effect on February 22nd, 2010.

Previously it was common practice to count one day of time served in pre-trial detention (remand) as two days of sentenced custody.

The Bill notes that in general cases judges may provide one day of credit for one day of time served in remand.

What is the effect of Bill C-25 on the number of people in remand, provincial sentenced custody and federal sentenced custody?

A remand credit model



Queue network model characteristics

- Entities with attributes
- Volumes at main stages
- Time measurements are important
  - Wait-times
- Quantitative
  - Averages insufficient
  - Distributional information
  - Correlations between remand and sentences
- Data hungry

What is a queue ?

- Queue consists of one or more servers processing "customers" and the group of "customers" waiting for service.
- It is defined by the arrival process, service process and the number of servers (for example M/M/5) and the "service discipline" (for example "first in, first out")
- Time spent in a queue is a dynamical property dependent on both, fixed properties of the queue and the state of queue at any given time (i.e. number of other customers waiting for service).
- Equilibrium state of a queue is best described in terms of distributions.
- Number of queues linked together form a queuing network

Arrival and service processes

- Arrival processes could be:
  - Deterministic (another widget comes down the production line every 2 minutes)
  - Stochastic (people arriving to a checkout at the supermarket)
    - Markovian: present is past and future independent. I.e. "Interarrival times sample Poisson distribution".
- A lot of queues have Markovian arrival processes.
- Service processes are likewise diverse, but fewer systems have strictly Markovian services.
  - Another popular distribution that can be sampled for service times is "Weibull" which is a generalization of "Poisson" distribution.
- When modelling, arrival and service time distributions most often have to be inferred from the system data

Advantages of the queue network modelling

- Because results are distributional, it is possible to account for the situations going beyond the average state of the system.
  - Consider hospital emergency room
    - Short average waiting times are not very good if people arriving at certain times have to wait unacceptably long for service.
  - Or a prison
    - Being "at capacity" on average is not good enough if facility is overcrowded half the time
- Easier to account for system resources

Incarceration as a queuing network

- Arrival into the criminal justice system is well modelled by a Poisson process.
- Prison sentence can be considered an operation of a server.
  - Non Poisson service time.
- What about remand custody ?
  - Can be made up of a number of in-and-out of jail periods separated by interim release hearings and breach events.
  - Duration of each individual stint in jail turns out to be close to Poisson distributed.
  - It is possible to calculate the overall distribution of time spent in pre-sentence custody from atomic properties of individual stints in jail.

Impact of correlations

- Given the distribution of pre-sentence incarceration, credit rules and the distribution of sentences it should be easy to calculate overall distribution for occupancy of prison facilities.
- But remand stay and eventual prison sentence are not independent.
  - Individuals with longer remand stays are also more likely to receive custody sentences and to have longer custody sentences
- Model which does not take this dependency into account will under estimate the impact of the change in sentence credit.
  - This can not be accounted for in a non-agent based model
  - In context of queuing theory model it is addressed by fitting data to a "Bivariate Weibull" distribution.

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