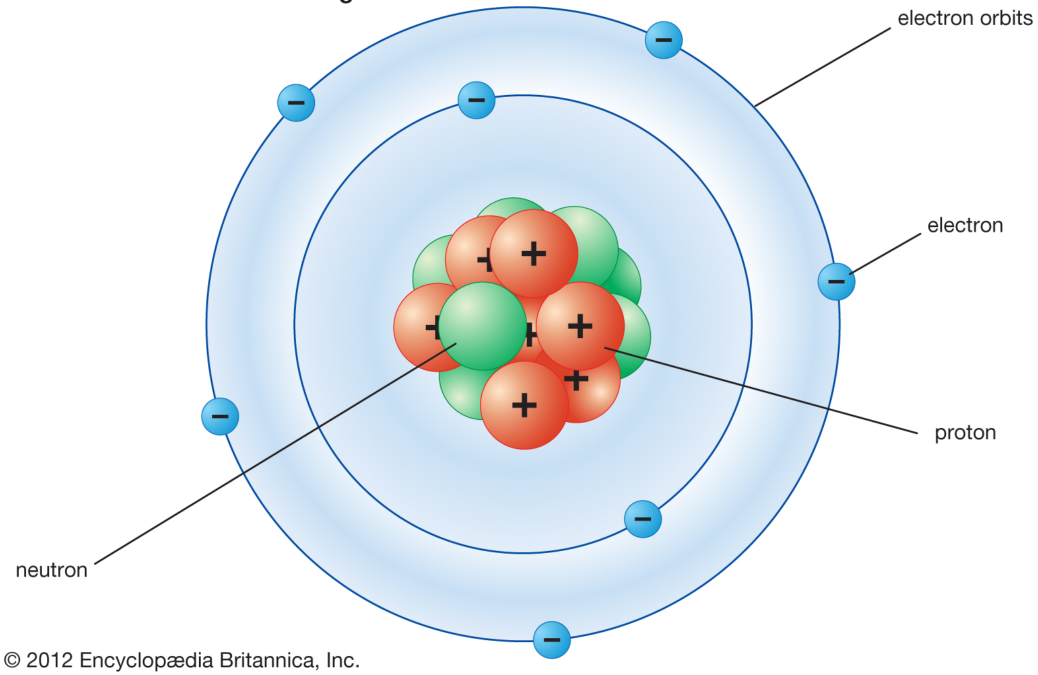
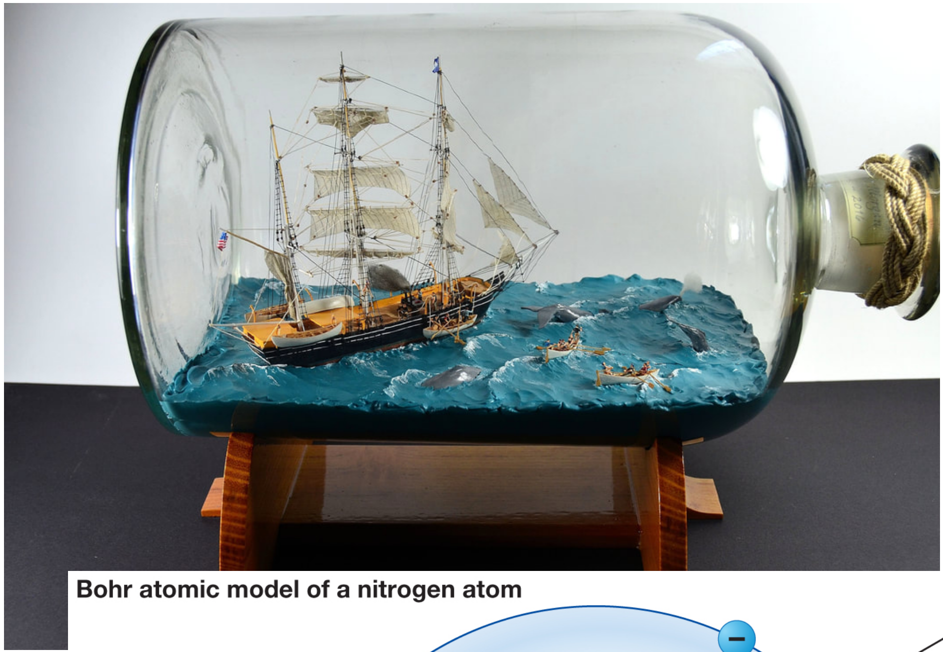
COMP1531

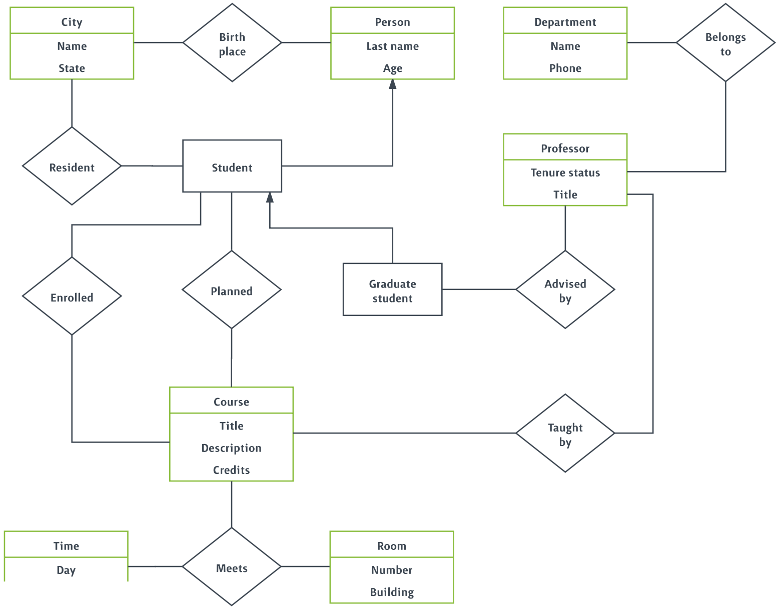
9.3 Modelling

What's a model?

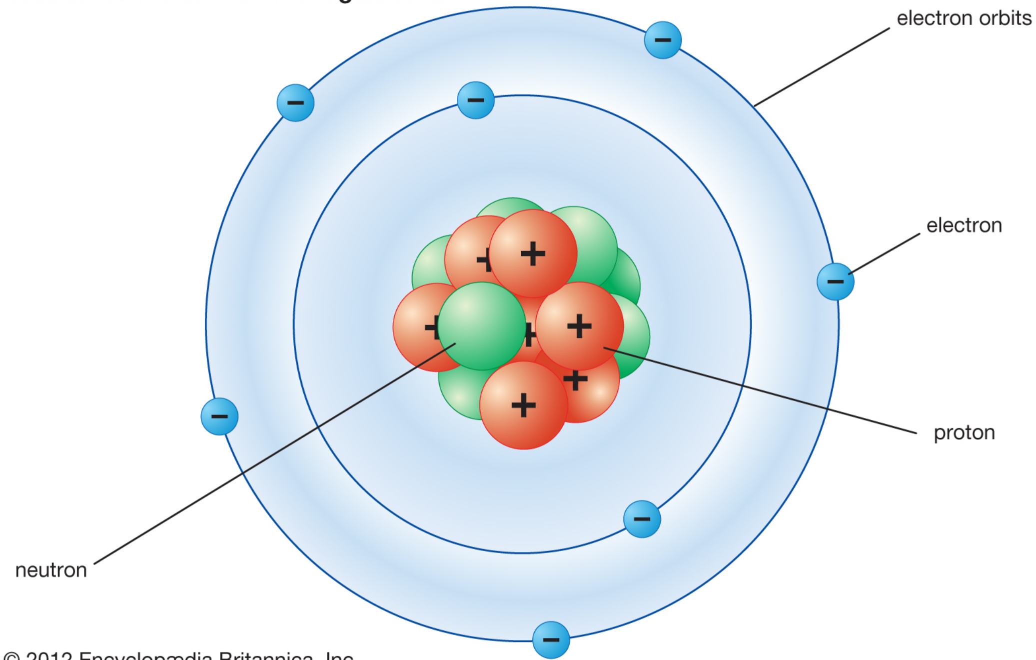
Bohr atomic model of a nitrogen atom

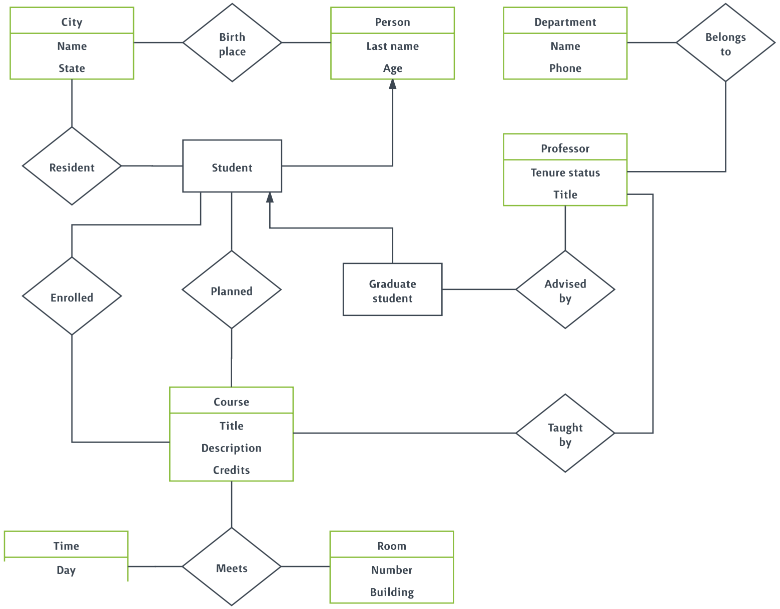




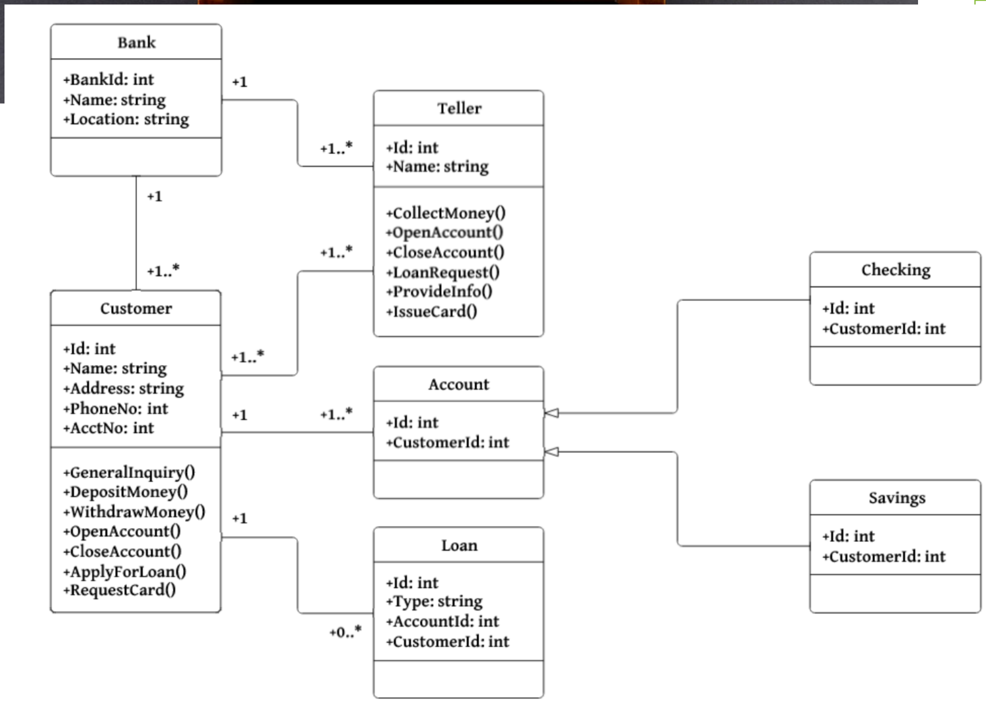


Bohr atomic model of a nitrogen atom



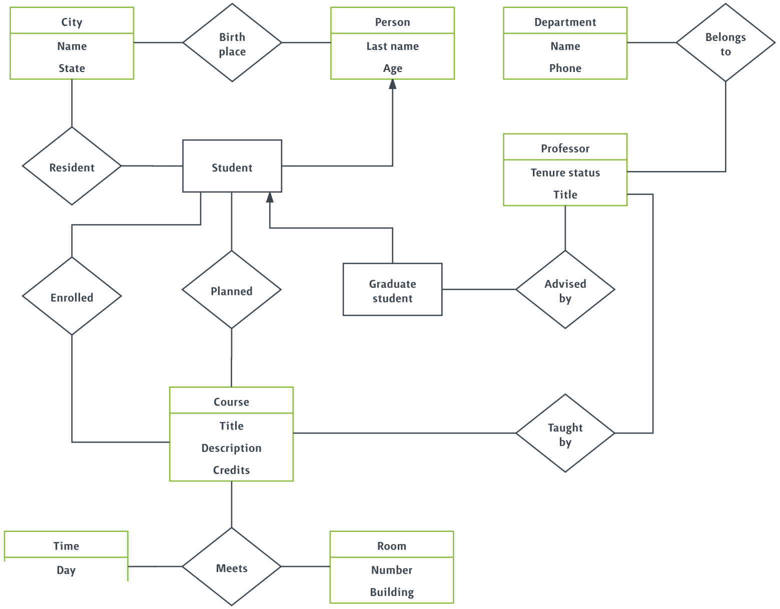


n orbits



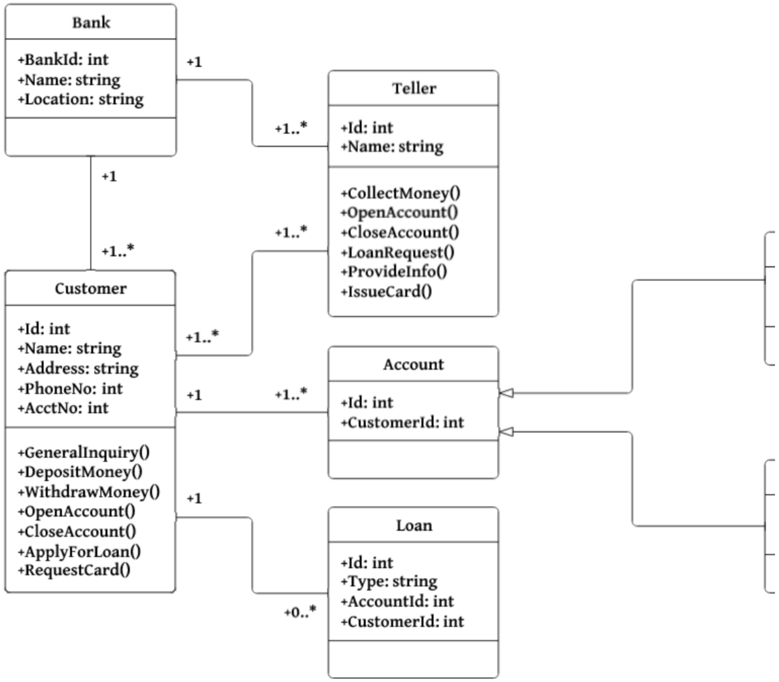
ctron

oton



City
Name
State
Birth place
Person
Last name
Age
Department
Name
Phone
Belongs to
Resident
Student
Professor
Tenure status
Title
Enrolled
Planned
Graduate student
Advised by
Course
Title
Description
Credits
Taught by
Time
Day
Meets
Room
Number
Building

on orbits



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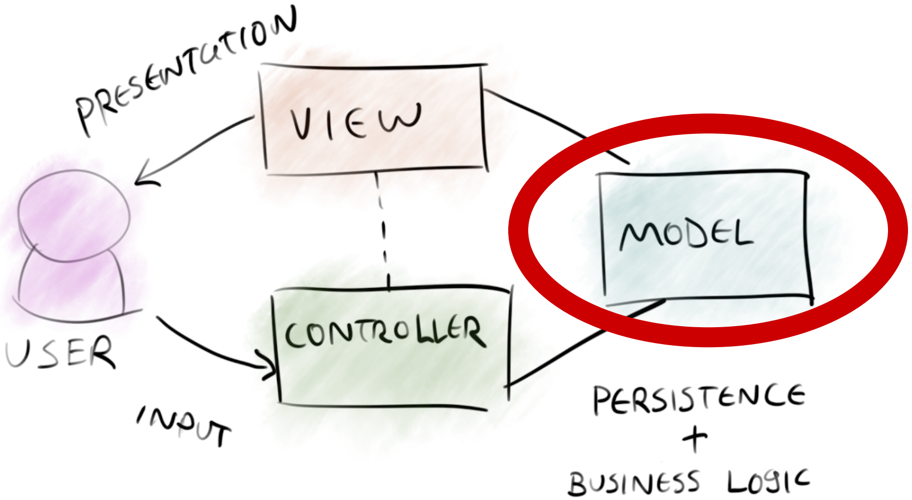
+BankId: int
+Name: string
+Location: string
+1
+1..*
Teller
+Id: int
+Name: string
+CollectMoney()
+OpenAccount()
+CloseAccount()
+LoanRequest()
+ProvideInfo()
+IssueCard()
+1
+1..*
+1..*
Customer
+Id: int
+Name: string
+Address: string
+PhoneNo: int
+AcctNo: int
+GeneralInquiry()
+DepositMoney()
+WithdrawMoney()
+OpenAccount()
+CloseAccount()
+ApplyForLoan()
+RequestCard()
+1..*
+1
+1..*
Account
+Id: int
+CustomerId: int
+1
+0..*
Loan
+Id: int
+Type: string
+AccountId: int
+CustomerId: int



PRESENTATION
VIEW
USER
MODEL
CONTROLLER
INPUT
PERSISTENCE
+
BUSINESS LOGIC

Figure 1: Mathematical Model

$$\frac{dC}{dt} = \frac{s_c C}{1+(R_b+N_b+T_b+L_b)/b_{c\infty}} + \frac{k_{cp}}{v_m}(P-C) - (k_{crc}+k_{cnc}+k_{ctc}+k_{clc})C - \mu_c C$$

$$\frac{dP}{dt} = \frac{k_{cp}}{v_b}(C-P) - \mu_p P$$

$$\frac{dR_c}{dt} = \frac{s_{rc}R_c}{1+R_b/b_{r\infty}} + k_{crc}C - k_{rcm}R_c - \mu_{rc}R_c \qquad \frac{dR_m}{dt} = k_{rcm}R_c - \frac{k_{rmb}}{v_m}R_m - \mu_{rm}R_m$$

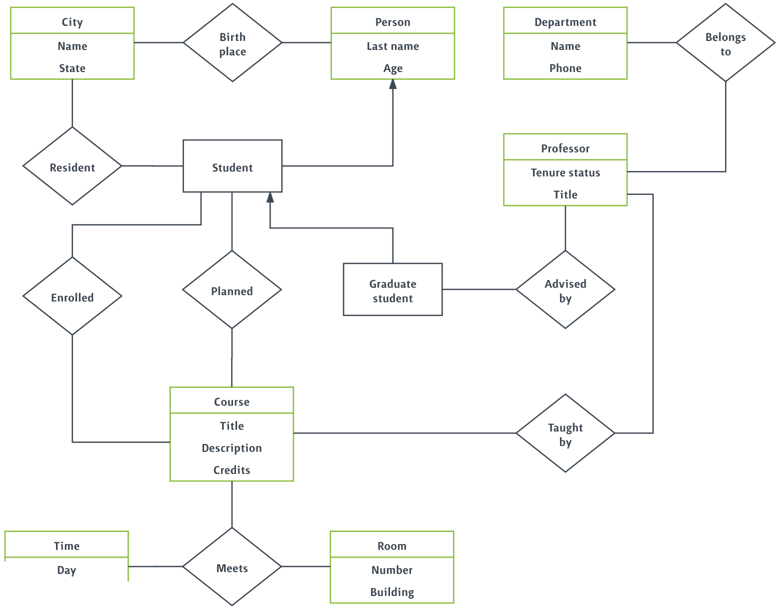
$$\frac{dN_c}{dt} = \frac{s_{nc}N_c}{1+N_b/b_{n\infty}} + k_{cnc}C - k_{ncm}N_c - \mu_{nc}N_c \qquad \frac{dN_m}{dt} = k_{ncm}R_c - \frac{k_{nmb}}{v_m}N_m - \mu_{nm}N_m$$

$$\frac{dT_c}{dt} = \frac{s_{tc}T_c}{1+T_b/b_{t\infty}} + k_{ctc}C - k_{tcm}T_c - \mu_{tc}T_c \qquad \frac{dT_c}{dt} = k_{tcm}T_c - \frac{k_{tmb}}{v_m}T_c - \mu_{tc}T_c$$

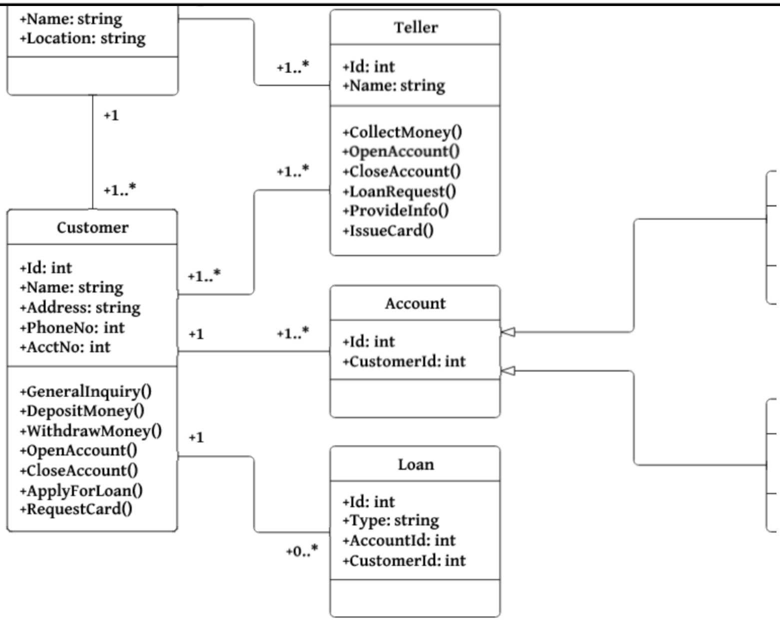
$$\frac{dL_c}{dt} = \frac{s_{lc}L_c}{1+L_b/b_{l\infty}} + k_{clc}C - k_{lcm}L_c - \mu_{lc}L_c \qquad \frac{dL_c}{dt} = k_{lcm}L_c - \frac{k_{lmb}}{v_m}L_c - \mu_{lc}L_c$$

$$\frac{dR_b}{dt} = \frac{k_{rmb}}{v_m}R_m - \mu_{rb}R_b \qquad \frac{dT_b}{dt} = \frac{k_{tmb}}{v_m}T_m - \mu_{tb}T_b$$

$$\frac{dN_b}{dt} = \frac{k_{nmb}}{v_m}N_m - \mu_{nb}N_b \qquad \frac{dL_b}{dt} = \frac{k_{lmb}}{v_m}L_m - \mu_{lb}L_b$$



ɔn orbits



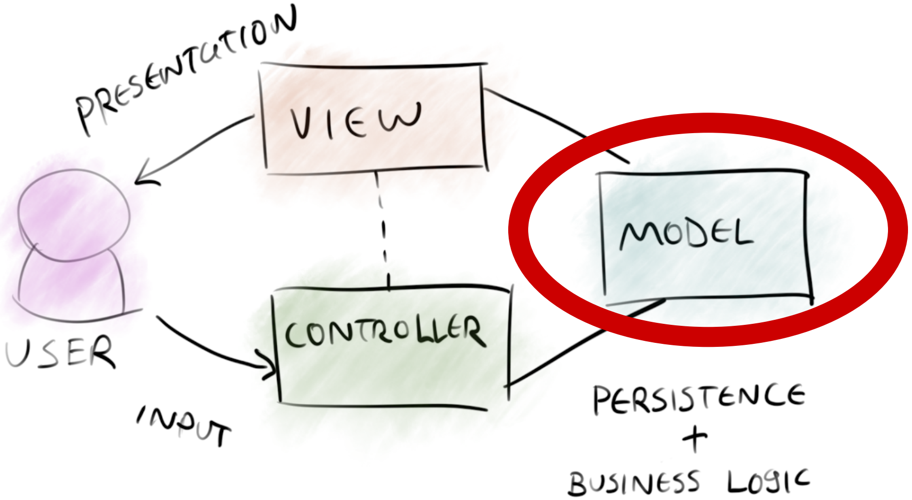


Figure 1: Mathematical Model

$$\frac{dC}{dt}=\frac{s_c C}{1+(R_b+N_b+T_b+L_b)/b_{c\infty}}+\frac{k_{cp}}{v_m}(P-C)-(k_{crc}+k_{cnc}+k_{ctc}+k_{clc})C-\mu_c C$$

$$\frac{dP}{dt}=\frac{k_{cp}}{v_b}(C-P)-\mu_p P$$

$$\frac{dR_c}{dt}=\frac{s_{rc}R_c}{1+R_b/b_{r\infty}}+k_{crc}C-k_{rcm}R_c-\mu_{rc}R_c \qquad \frac{dR_m}{dt}=k_{rcm}R_c-\frac{k_{rmb}}{v_m}R_m-\mu_{rm}R_m$$

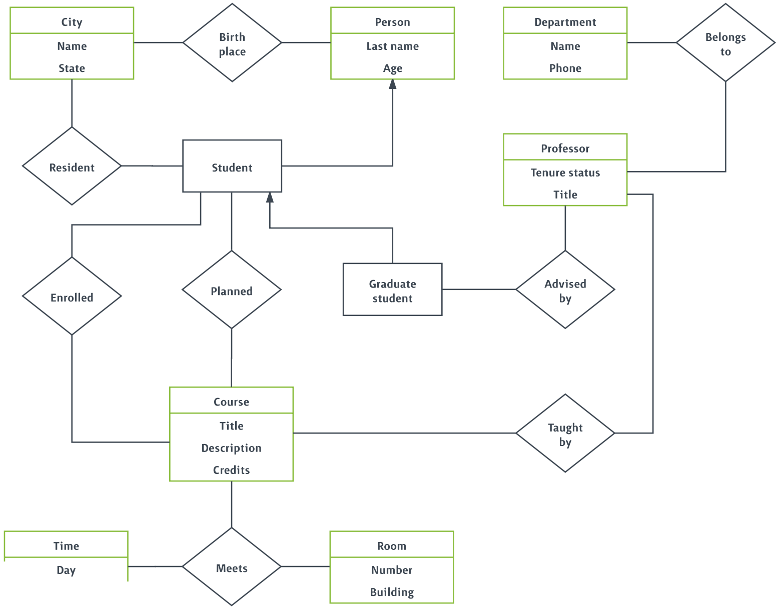
$$\frac{dN_c}{dt}=\frac{s_{nc}N_c}{1+N_b/b_{n\infty}}+k_{cnc}C-k_{ncm}N_c-\mu_{nc}N_c \qquad \frac{dN_m}{dt}=k_{ncm}R_c-\frac{k_{nmb}}{v_m}N_m-\mu_{nm}N_m$$

$$\frac{dT_c}{dt}=\frac{s_{tc}T_c}{1+T_b/b_{t\infty}}+k_{ctc}C-k_{tcm}T_c-\mu_{tc}T_c \qquad \frac{dT_c}{dt}=k_{tcm}T_c-\frac{k_{tmb}}{v_m}T_c-\mu_{tc}T_c$$

$$\frac{dL_c}{dt}=\frac{s_{lc}L_c}{1+L_b/b_{l\infty}}+k_{clc}C-k_{lcm}L_c-\mu_{lc}L_c \qquad \frac{dL_c}{dt}=k_{lcm}L_c-\frac{k_{lmb}}{v_m}L_c-\mu_{lc}L_c$$

$$\frac{dR_b}{dt}=\frac{k_{rmb}}{v_m}R_m-\mu_{rb}R_b \qquad \frac{dT_b}{dt}=\frac{k_{tmb}}{v_m}T_m-\mu_{tb}T_b$$

$$\frac{dN_b}{dt}=\frac{k_{nmb}}{v_m}N_m-\mu_{nb}N_b \qquad \frac{dL_b}{dt}=\frac{k_{lmb}}{v_m}L_m-\mu_{lb}L_b$$



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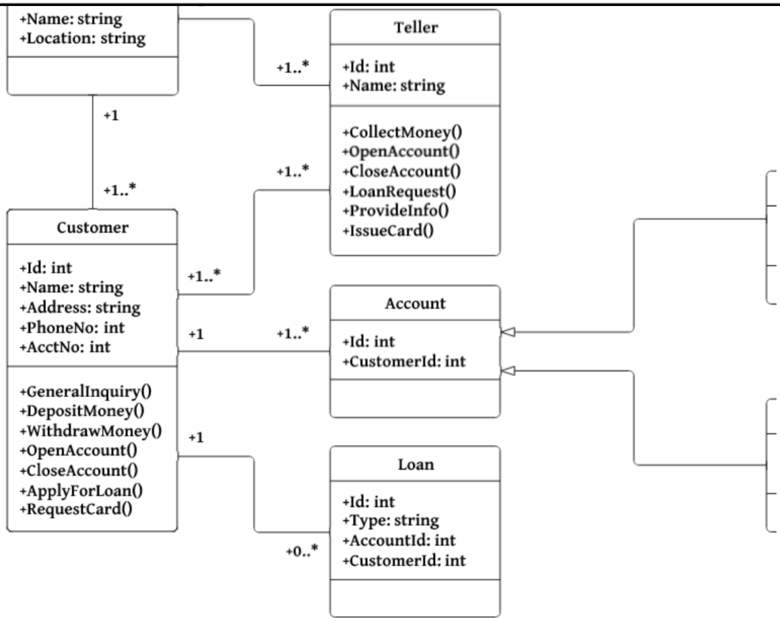

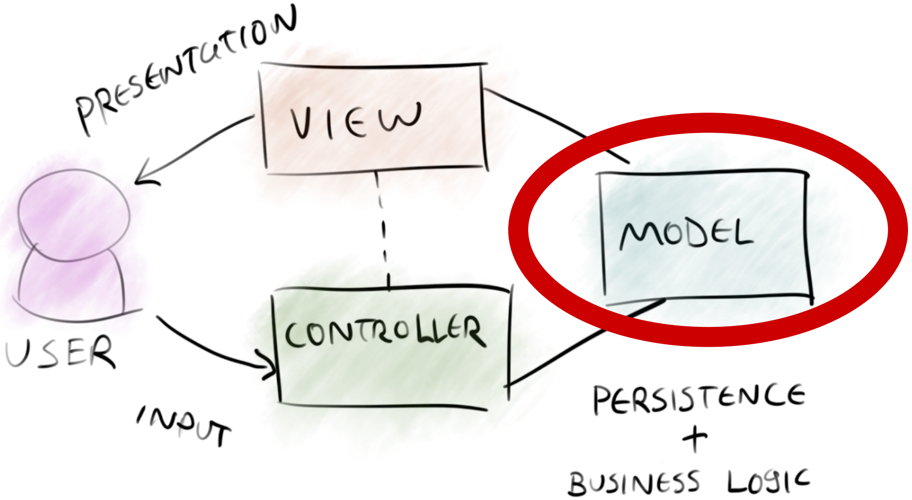

Conceptual Modelling

- *A model that is conceptual*
  - *… with a real world correspondence*
  - *… without a real world correspondence*
- *A model of a concept*

Conceptual models software engineers care about

- Data models
- Mathematical models
- Domain models
- Data flow models
- State transition models (today)

How models are used

- To predict future states of affairs.
- Understand the current state of affairs.
- Determine the past state of affairs.
-

Communicating models

- Four fundamental objectives of communicating with a conceptual model:
  1. Enhance an individual's understanding of the representative system
  2. Facilitate efficient conveyance of system details between stakeholders
  3. Provide a point of reference for system designers to extract system specifications
  4. Document the system for future reference and provide a means for collaboration

Kung and Solvberg (1986)

System Modelling

- Structural – Emphasise the static structure of the system
  - UML class diagrams
  - ER diagrams
  - … many others
- Behavioural - Emphasise the dynamic behaviour
  - State diagrams
  - … some others

State Machines

- Machines made up of a finite number of states.
- The machine can be *transitioned* from one state to another
- Simple example: a door

State diagrams

- A diagrammatic representation of a state.
- Some variation in notation.
- Typically: states are circles, transitions are labelled arrows connecting them

State machines

- Useful for modelling systems that have clearly defined states. For example:
  - UIs with different screens
  - Network protocols
  - Conversational interfaces

Parking meter

Parking meter

Opal Card

- Can we model the opal card system as a state machine?