Using ExtendSim
ExtendSim Environment

- ExtendSim is a complete simulation environment that runs under Windows
  - Supports both continuous and discrete simulation
  - Employs a multi-window graphical user interface for assembling model structure
    - The primary technique for laying in a model is "drag and drop" using blocks from supplied libraries
- Block elements include a dialogue, iconics, and procedural routines
  - Double-clicking on a block opens its dialogue window
  - The procedural routines are written in a "C-like" language called ModL
- Library blocks, including their procedural routines are fully accessible and can be copied and modified for special purposes
Single Server Queue

- Basic graphical layout for a *single-server queue*

- Model "Executive" block (in the *Item.lix* library)
- Configurable "Create" block (in the *Item.lix* library) for bringing items into the model
- "Queue" block (in the *Item.lix* library) for receiving items in the model flow – default protocol is FIFO
- "Exit" block (in the *Item.lix* library) for removing items from the model
- Configurable "Activity" block (in the *Item.lix* library) for modeling activities such as a server action
- "Random Number" block (in the *Value.lix* library) for sampling from probability distributions (use in this manner is optional)
Setup for Building a Model

• Clicking File … New Model in the ExtendSim interface opens a new model window

• Blocks for a model are obtained from library files
  – The most commonly used libraries of blocks for discrete event simulation are named Item.lix and Value.lix

• Clicking Library … Open Library is used to access the library files
  – Once a library is open, it will appear in a list under the Library tab, from which a library access window can be opened for drag & drop of library blocks to the model

• ExtendSim can be configured to automatically open libraries (and access windows) on launch via Edit … Options … Libraries
ExtendSim Elements

• **Items** are simply the basic discrete event units that are passed between blocks

• **Values** are actual data generated or used in the model as it operates

• **Block connections**
  – Connect from item output to item input
    • E.g., the item output of a Generator Block to the item input of a Queue Block
  – Connect from value output to value input
    • E.g., connect the value output from a Random Number block to the delay value input of an Activity block
Connecting Blocks

- There are two basic types of connectors for blocks in ExtendSim:
  - item input and output connectors
  - value input and output connectors
- A connector with a small triangle is a multiple connector
  - click & drag on the triangle produces the additional connections
- There are other, less commonly used types of connectors
Making Connections

• On the model this is done using the “drawing pen”
  – Appears when the block/text layer tool is placed over a connector
  – Use standard “click and drag” from one connector to another of opposite type causes a tentative connection line which darkens when a connection match is made
  – Releasing the mouse button causes the connection line to affix between the two points.

• Different types of connection lines can be configured by use of the **Model … Connection Lines** tab
Running an ExtendSim Model

- The simulation is started by
  - clicking the run icon on the task bar or
  - by executing "run" from the run tab
    - a simulation, even in its initial set up will almost always run, but until configuration details and output display are in place it will not do anything particularly meaningful
- The "Show 2D Animation" section under the run tab provides means for configuring the simulation graphics to show simulation progress as the simulation executes
  - Useful in initial stages of simulation construction
  - 2D Simulation effects can be toggled on/off from the task bar
Block Dialogue

• To bring up a block's dialogue, just double-click on it
  – The dialogue is where any permitted configuration values are set (in some cases, configuration values can be adjusted "on the fly" by use of prescribed "block inputs")
About the Blocks in the Basic Single Server Queue Model
Executive Block

- The Executive block (*Item.lix*) is required for discrete event models in ExtendSim
- It must be placed to the left of all other blocks in the model
- It can be configured for a stop criteria other than simulation run length
Create Block

- The Create block (*Item.lix*) is used to bring items into the model
- A Create block is configured via its dialogue window (obtained by double-clicking the block)
  - The distribution governing item generation (including empirical) is selected just by clicking on the distribution input box
  - Any parameters required by the distribution can then be set
  - Note that for animation, the animation figure can be any one of a number of different representations
The Queue block (Item.lix) is used as a bin for holding items (temporarily) blocked from proceeding
- For example, items waiting for a server

The queuing protocol to be used for releasing items is specified in the Queue block’s dialogue
- Default is first in, first out (FIFO)
- Others include last in, first out (LIFO – the protocol used by a stack), priority, and by attribute
Activity Block

- The Activity Block is used to delay one or more items from progressing in the model
  - Typically, a server is represented by an activity delay
  - The maximum number of items allowed in the block (set in the block’s dialogue window) corresponds to the number of servers the block represents
  - The delay amount for each item can be input through the D connector

- The block allows a variety of modeling capabilities (via its dialogue), including dynamically changing the maximum number of items and item pre-emption (exiting an item before completing its prescribed delay)
Random Number Block

- As for the Create Block, double-click on a “Random Number” block (Value.lix) to bring up its dialog and set the distribution (including empirical) to be sampled from.
Exit Block

• Items are exited from the model using an Exit block
  – The total number exited is displayed and output by the block

• The block can be configured to have more than one exit
  – Useful for counting items of differing characteristics as they exit the model
Additional Model Considerations
Timed Simulation Model

- The overall simulation can be set up as a "timed" simulation via the Run … Simulation Setup…Setup tab.

- If the setup is configured for "hours" and the Create blocks (Item.lix) and Activity blocks (Item.lix) are configured for "minutes", ExtendSim will automatically take care of the time conversions.
Simulation Time Units

- The **Setup** tab under the Simulation Setup provides the means for changing how time conversions are done (e.g., to have 8 hour days, rather than 24 hour days)
Untimed Simulation

- Setting up a simulation to be untimed is one of the options in the dialogue of the Executive block (Item.lix)
  - Permits the stop criteria to be a value input through the count connector
  - Selecting the count connector option causes an input value connector for the count to appear on the Executive
Generating a Stop Signal

• A Pulse (*Item.lix*) block can be used to send a signal to the Executive Block to stop a simulation.
The ExtendSim Display

• A display or I/O box in a block's dialogue can be "cloned" onto the model display (actually residing in the "Clone" layer) by using the clone tool to drag a copy from the dialogue onto the model display.

• There are actually three "layers" on the display, each with its own tool:
  – Block/Text layer
  – Draw layer
  – Clone layer

• There is also an "all layers" tool for positioning items for best line-up across layers.
Cloned Item Behavior

- Once a dialogue box is cloned onto the display, the “all layers” tool can be used to resize and position it appropriately.

- As the simulation executes, the values in the cloned display box change dynamically
  - Same is true if the dialogue is left open.
Built-in Controls

- Under the **Model … Controls** tab there are 3 controls:
  - **Slider**
    - a graphical display for producing a value in a (min, max) range
  - **Switch**
    - a graphical display for producing a 0 or 1 value (true or false)
  - **Meter**
    - a graphical display for exhibiting a value

- Useful for public display purposes
Some Useful Data Value Blocks

- The “Constant” block \( (Value.lix) \) outputs a set value that can be used in computations or for input parameters.

- The “Simulation Variable” block \( (Value.lix) \) outputs the value of the system variable selected in its dialogue (e.g., current simulation time).

- The “Display Value” block \( (Value.lix) \) displays the value of an input value.
  - **Warning**: if this block is attached to a Random Number block also being used by some other block, it will pull its own random value rather than displaying the one provided to the other block.
Mean & Variance Block

• The “Mean & Variance” block (*Value.lix*) is used to produce running statistical information on values input to the block
  – The mean is placed at the output labeled \( M \)
  – The variance is placed at the output labeled \( V \)
  • An output connector with a small triangle is a multiple output; click & drag on the triangle produces the additional outputs
Information Block

- Used to gather information about items
- Can be set up to gather and output various item statistics
  - Signal an item passing through
  - Count of number of items
  - Interarrival time between items
  - Time in activity (via a specified attribute)
Arithmetic Calculations

• The Math Block (*Value.lix*) can be used to perform a number of standard operations on the values input
  – Add, subtract, multiply, divide, exponentiate, logarithm
  – And, or, not
  – Trigonometric functions and a number of others
Equation Blocks

• There is a general "Equation" block (`Value.lix`) for calculating expressions of the form `result = formula`;
  – Can be configured via its block dialogue for as many inputs as needed
  – ExtendSim's operators are:
    • +, -, *, /
    • ^ (exponentiation), MOD or % (modulus)
    • AND or &&, OR or ||, NOT or !
    • == (equals), != or <> (not equal)
    • <, <=, >, >=

• There’s also an “Equation(I)” block (`Item.lix`) for use with discrete event objects
  – Can access use item attributes as well as input values
Simulation Reporting (1)

• ExtendSim provides a crude report generator under the Run tab
  – Report information is generated block by block for those blocks the user has selected
    • to select multiple blocks at once, click on them while holding the shift key
    • under the Run tab click on "Add Selected to Report"
  – Reporting only gives final values
  – There is a (voluminous) model tracing capability under Run .. Debugging if intermediate values are of interest