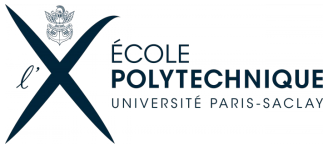
GEANT4
A SIMULATION TOOLKIT

Version 11.0

Definition of UI commands

Makoto Asai (Jefferson Lab)
Geant4 Tutorial Course



Jefferson Lab
Thomas Jefferson National Accelerator Facility

PRINCETON
UNIVERSITY

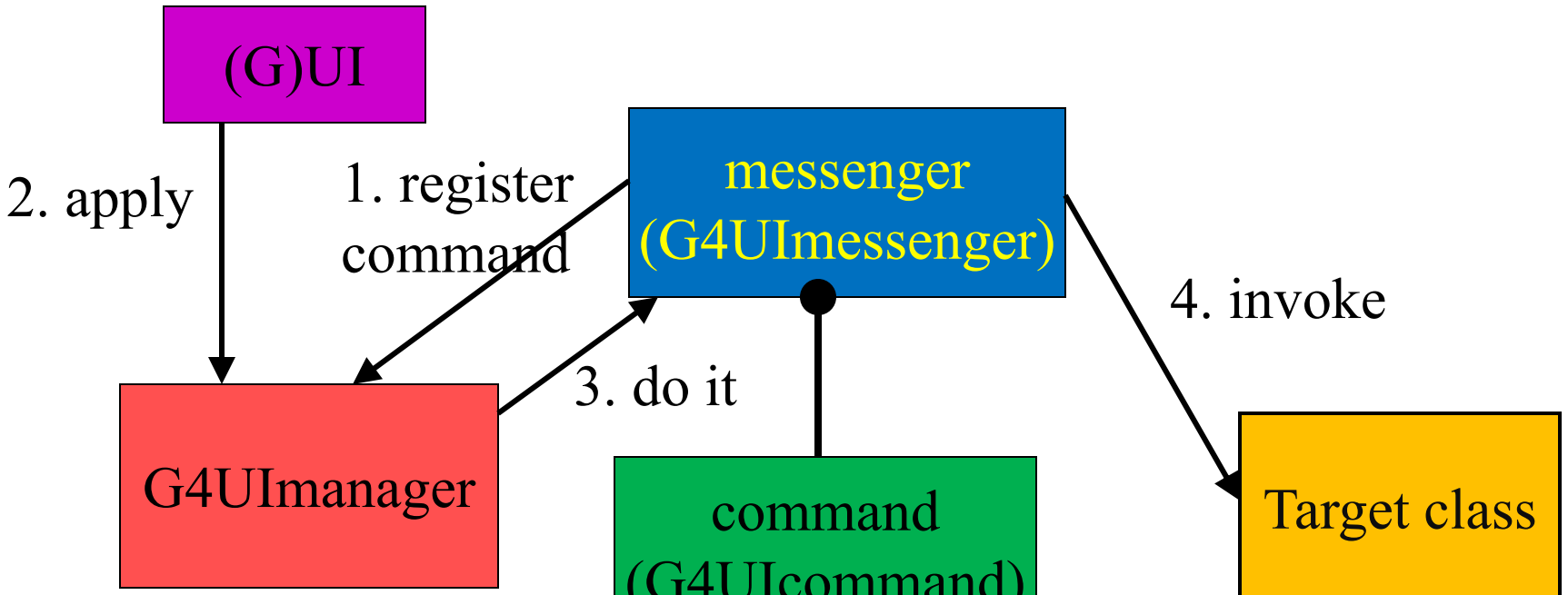
Contents

- Mechanism of UI command
- Defining basic UI command
- Defining complicated UI command
- G4GenericMessenger
- UI command in multithreaded mode
- Some useful UI control commands

Contents

- Mechanism of UI command
- Defining basic UI command
- Defining complicated UI command
- G4GenericMmessenger
- UI command in multithreaded mode
- Some useful UI control commands

Mechanism of UI command



To define user's command :

- Object shown in green must be instantiated by the user

- Class shown in blue must be implemented and instantiated by the user

Messenger class

- Each messenger class must be derived from G4UImessenger base class. A messenger class can handle more than one UI commands.
- A messenger class should be instantiated by the constructor of the target class to which commands should be delivered, and should be deleted by the destructor of the target class.
- Methods of messenger class
  - Constructor
    - Define (instantiate) commands / command directories
  - Destructor
    - Delete commands / command directories
  - void SetNewValue(G4UIcommand* command, G4String newValue)
    - Convert "newValue" parameter string to appropriate value(s) and invoke an appropriate method of the target class
    - This method is invoked when a command is issued.
  - G4String GetCurrentValue(G4UIcommand* command)
    - Access to an appropriate get-method of the target class and convert the current value(s) to a string
    - This method is invoked when the current value(s) of parameter(s) of a command is asked by (G)UI.

Contents

- Mechanism of UI command
- Defining basic UI command
- Defining complicated UI command
- G4GenericMessenger
- UI command in multithreaded mode
- Some useful UI control commands

Definition (instantiation) of a command

- To be implemented in the constructor of a messenger class.

```
A01DetectorConstMessenger::A01DetectorConstMessenger
(A01DetectorConstruction* tgt)
:target(tgt)
{
  mydetDir = new G4UIdirectory("/mydet/");
  mydetDir->SetGuidance("A01 detector setup commands.");

  armCmd = new G4UIcmdWithADoubleAndUnit("/mydet/armAngle",
                   this);
  armCmd->SetGuidance("Rotation angle of the second arm.");
  armCmd->SetParameterName("angle",true);
  armCmd->SetRange("angle>=0. && angle<180.");
  armCmd->SetDefaultValue(30.);
  armCmd->SetDefaultUnit("deg");
}
```

- Guidance can (should) be more than one lines. The first line is used as a short description of the command.

G4UIcommand and its derivatives

- G4UIcommand is a class which represents a UI command. G4UIparameter represents a parameter.
- G4UIcommand can be directly used for a UI command. Geant4 provides its derivatives according to the types of associating parameters. These derivative command classes already have necessary parameter class object(s), thus you don't have to instantiate G4UIparameter object(s).
  - G4UIcmdWithoutParameter
  - G4UIcmdWithAString
  - G4UIcmdWithABool
  - G4UIcmdWithAnInteger
  - G4UIcmdWithADouble, G4UIcmdWithADoubleAndUnit
  - G4UIcmdWith3Vector, G4UIcmdWith3VectorAndUnit
  - G4UIdirectory
- A UI command with other type of parameters must be defined by G4UIcommand base class with G4UIparameter.

Parameter name(s)

- These methods are available for derivative command classes which take parameter(s).

```
void SetParameterName(
    const char*parName,
    G4bool omittable,
    G4bool currentAsDefault=false);
void SetParameterName(
    const char*nam1, const char*nam2, const char*nam3,
    G4bool omittable,
    G4bool currentAsDefault=false);
```

- Parameter names are used in help, and also in the definition of parameter range.
- If "omittable" is true, the command can be issued without this particular parameter, and the default value will be used.
- If "currentAsDefalult" is true, current value of the parameter is used as a default value, otherwise default value must be defined with SetDefaultValue() method.

Range, unit and candidates

```
void SetRange(const char* rangeString)
```

- Available for a command with numeric-type parameters.
- Range of parameter(s) must be given in C++ syntax.

```
aCmd->SetRange("x>0. && y>z && z<(x+y)");
```

- Not only comparison with hard-coded number but also comparison between variables and simple calculation are available.
- Names of variables must be defined by SetParameterName() method.

```
void SetDefaultUnit(const char* defUnit)
```

- Available for a command which takes unit.
- Once the default unit is defined, no other unit of different dimension will be accepted.
- Alternatively, you can define a dimension (unit category) without setting a default unit.

```
void SetUnitCategory(const char* unitCategory)
```

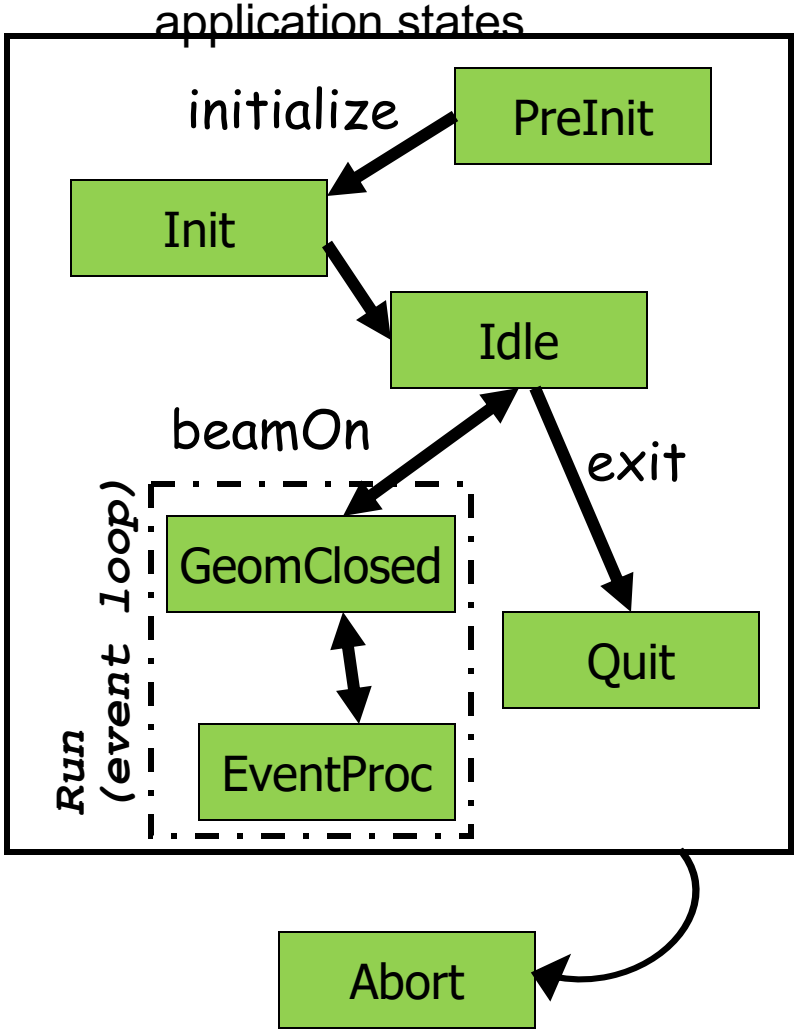
```
void SetCandidates(const char* candidateList)
```

- Available for a command with string type parameter
- Candidates must be delimited by a space.
- Candidates can be dynamically updated.

Available state

`void AvailableForStates(G4ApplicationState s1,…)`

- Define command's applicability for Geant4
- Geant4 has six application states.
  - G4State_PreInit
    - Initial condition
  - G4State_Init
    - During initialization
  - G4State_Idle
    - Ready to start a run
  - G4State_GeomClosed
    - Geometry is optimized and ready to process an event
  - G4State_EventProc
    - An event is processing
  - G4State_Quit, G4State_Abort
    - UI command unavailable



Conversion between string and values

- Derivatives of G4UIcommand with numeric or boolean parameters have corresponding conversion methods.
- From a string to value

```
G4bool GetNewBoolValue(const char*)
G4int GetNewIntValue(const char*)
G4double GetNewDoubleValue(const char*)
G4ThreeVector GetNew3VectorValue(const char*)
```

  - To be used in SetNewValue() method in messenger.
  - Unit is taken into account automatically.
- From value to string

```
G4String ConvertToString(...)
G4String ConvertToString(...,const char* unit)
```

  - To be used in GetCurrentValue() method in messenger.

SetNewValue and GetCurrentValue

```
void A01DetectorConstMessenger
::SetNewValue(G4UIcommand* command,G4String newValue)
{
  if( command==armCmd )
  { target->SetArmAngle(armCmd
        ->GetNewDoubleValue(newValue)); }
}

G4String A01DetectorConstMessenger
::GetCurrentValue(G4UIcommand* command)
{
  G4String cv;
  if( command==armCmd )
  { cv = armCmd->ConvertToString(
            target->GetArmAngle(),"deg"); }
  return cv;
}
```

Contents

- Mechanism of UI command
- Defining basic UI command
- Defining complicated UI command
- G4GenericMessenger
- UI command in multithreaded mode
- Some useful UI control commands

Complicated UI command

- Complicated UI command means a UI command with parameters which is not included in the deliverable classes.
  - G4UIcmdWithoutParameter, G4UIcmdWithAString, G4UIcmdWithABool, G4UIcmdWithAnInteger, G4UIcmdWithADouble, G4UIcmdWithADoubleAndUnit, G4UIcmdWith3Vector, G4UIcmdWith3VectorAndUnit
- A UI command with other type of parameters must be defined by G4UIcommand base class with necessary numbers of G4UIparameter.

  G4UIparameter(const char * parName,
  char theType, G4bool theOmittable);
  - “parName" is the name of the parameter which will be used by the range checking and help
  - "theType" is the type of the parameter.
    - ‘b’ (boolean), ‘i’ (integer), ‘d’ (double), or ‘s’ (string)
  - Each parameter can take one line of guidance, a default value in case “theOmittable” is true, a range (for numeric type parameter), and a candidate list (for string type parameter).

Complicated UI command

- A G4UIcommand object can take arbitrary number of G4UIparameter objects.
  - Names of parameter must be different to each other (within the command).
  - It takes arbitrary number of guidance lines.
  - Availability for Geant4 states can be set.
  - In addition to ranges defined to individual parameters, it may take another range definition where values of more than one parameters can be compared to others.
- When you define a parameter that is used as a unit,
  - G4UIparameter::SetDefaultUnit() should be used to specify the default unit as well as the dimension.
  - Once the default unit is defined, no other unit of different dimension will be accepted.

/gun/ion command

```
ionCmd = new G4UIcommand("/gun/ion",this);
ionCmd->SetGuidance("Set properties of ion to be generated.");
ionCmd->SetGuidance("[usage] /gun/ion Z A Q E");
ionCmd->SetGuidance("  Z:(int) AtomicNumber");
ionCmd->SetGuidance("  A:(int) AtomicMass");
ionCmd->SetGuidance("  Q:(int) Charge of Ion in unit of e (-1
                                                    for Z)");
ionCmd->SetGuidance("  E:(double) Excitation energy (in keV)");

G4UIparameter* param;
param = new G4UIparameter("Z",'i',false);
ionCmd->SetParameter(param);
param = new G4UIparameter("A",'i',false);
ionCmd->SetParameter(param);
param = new G4UIparameter("Q",'i',true);
param->SetDefaultValue("-1");
ionCmd->SetParameter(param);
param = new G4UIparameter("E",'d',true);
param->SetDefaultValue("0.0");
ionCmd->SetParameter(param);
```

Parameters are registered by their orders.

Converting string to values

- For complicated command, convenient conversion method is not available. Use G4Tokenizer to tokenize the string and convert each token to numerical values.

```
SetNewValue(G4UIcommand * command,G4String newValues)
{
   G4Tokenizer next( newValues );
    fAtomicNumber = StoI(next());
    fAtomicMass = StoI(next());
    G4String sQ = next();
    if (sQ.isNull()||sQ=="-1") {
        fIonCharge = fAtomicNumber;
    } else {
        fIonCharge = StoI(sQ);
        sQ = next();
        if (sQ.isNull()) {
            fIonExciteEnergy = 0.0;
        } else {
            fIonExciteEnergy = StoD(sQ) * keV;
        }
    }
    …
```

- G4UIcommand class has some basic conversion methods.
  - StoI() : convert string to int
  - StoD() : convert string to double
  - ItoS() : convert int to string
  - DtoS() : convert double to string
- Be careful of "omittable" parameters.

Contents

- Mechanism of UI command
- Defining basic UI command
- Defining complicated UI command
- G4GenericMessenger
- UI command in multithreaded mode
- Some useful UI control commands

G4GenericMessenger

- G4GenericMessenger is a short-cut for defining simple UI commands that are
  - associated with one target class, and grouped in one command directory
  - dealing only with native variable types (string, Boolean, integer, double) or G4ThreeVector.
- G4GenericMessenger is a concrete class you can just instantiate without implementing a dedicated messenger class.

```
class G4GenericMessenger : public G4UImessenger
{
public:
 G4GenericMessenger(void* obj, const G4String& dir = "", const G4String& doc = "");
 Command& DeclareProperty
   (const G4String& name, const G4AnyType& variable, const G4String& doc = "");
 Command& DeclarePropertyWithUnit
   (const G4String& name, const G4String& defaultUnit,
                          const G4AnyType& variable, const G4String& doc = "");
 Command& DeclareMethod
   (const G4String& name, const G4AnyMethod& fun, const G4String& doc = "");
 Command& DeclareMethodWithUnit
   (const G4String& name, const G4String& defaultUnit,
                          const G4AnyMethod& fun, const G4String& doc = "");
```

Target class object

Command directory

Target class data member

Target class public set method

Command name

example

```
B5PrimaryGeneratorAction::B5PrimaryGeneratorAction()
{
  fMessenger = new G4GenericMessenger(this,
                    "/B5/generator/",  "Primary generator control");

  // momentum command
  G4GenericMessenger::Command& momentumCmd
   = fMessenger->DeclarePropertyWithUnit("momentum", "GeV", fMomentum,
                                         "Mean momentum of primaries.");
  momentumCmd.SetParameterName("p", true);
  momentumCmd.SetRange("p>=0.");
  momentumCmd.SetDefaultValue("1.");
}

B5PrimaryGeneratorAction::~B5PrimaryGeneratorAction()
{
  delete fMessenger;
}
```

Data member of the target class

Contents

- Mechanism of UI command
- Defining basic UI command
- Defining complicated UI command
- G4GenericMessenger
- UI command in multithreaded mode
- Some useful UI control commands

UI command in multithreaded mode

- In multithreaded mode, each thread (both master and worker) has its own G4UImanager object.
  - Commands instantiated in a thread are registered to the G4UImanager of that thread.
- Every UI command is executed in the master thread if the command is issued in the master thread (including interactive session or macro file), and then broadcasted to each worker thread prior to the beginning of thread-local event loop (i.e. at the time of */run/beamOn*).
  - If the user wants to broadcast command(s) immediately, use */run/workersProcessCmds* command.
  - If a command should not be distributed to worker threads, *SetToBeBroadcasted(false)* should be set for that command.
  - If a command is hard-coded in an object in a worker thread, it is executed only in that worker thread. It won't be transmitted to other worker threads.

Contents

- Mechanism of UI command
- Defining basic UI command
- Defining complicated UI command
- G4GenericMessenger
- UI command in multithreaded mode
- Some useful UI control commands

Alias

- Alias can be defined by

  /control/alias [name] [value]

  – It is also set with **/control/loop** and **/control/foreach** commands

  – Aliased value is always treated as a string even if it contains numbers only.

- Alias is to be used with other UI command.

  – Use curly brackets, { and }.

  – For example, frequently used lengthy command can be shortened by aliasing.

```
/control/alias tv /tracking/verbose
{tv} 1
```

  – Aliases can be used recursively.

```
/control/alias file1 /diskA/dirX/fileXX.dat
/control/alias file2 /diskB/dirY/fileYY.dat
/control/getEnv runNo
/myCmd/getData {file{runNo}}
```

Get a shell variable value and define it as an alias

Loop

- **/control/loop** and **/control/foreach** commands execute a macro file more than once. Aliased variable name can be used inside the macro file.
- **/control/loop [*macroFile*] [*counterName*]**
  [*initialValue*] [*finalValue*] [*stepSize*]
  - *counterName* is aliased to the number as a loop counter
- **/control/foreach [*macroFile*] [*counterName*] [*valueList*]**
  - *counterName* is aliased to a value in *valueList*
  - *valueList* must be enclosed by double quotes (" ")

- on UI terminal or other macro file

```
/control/loop myRun.mac Ekin 10. 20. 2.
```

- in myRun.mac

```
/control/foreach mySingleRun.mac pname "p pi- mu-"
```

- in mySingleRun.mac

```
/gun/particle {pname}
/gun/energy {Ekin} GeV
/run/beamOn 100
```

Some other useful UI commands

- /control/shell *<shell_command>*
  - Execute a Unix shell command (e.g. */control/shell ls*)
- /control/getEnv *<shell_variable_name>*
  - Get a shell variable value and define it as an alias.
- /control/getVal *<alias_name> <UI_command> <index>*
  - Get the current value of the UI command and define it as an alias.
  - <index> is the index of the parameter to take if the command has more than one parameters.
- /control/add *<alias_name> <val_1> <val_2>*
- /control/subtract *<alias_name> <val_1> <val_2>*
- /control/multiply *<alias_name> <val_1> <val_2>*
- /control/divide *<alias_name> <val_1> <val_2>*
- /control/reminder *<alias_name> <val_1> <val_2>*
  - *<val_1> and/or <val_2>* can be aliases.
  - If *<alias_name>* already exists, value is overwritten.

Some other useful UI commands

- /control/doif *<val_1> <comp> <val_2> <UI_command>*
- /control/if *<val_1> <comp> <val_2> <macro_file>*
  - Equivalent to /control/doif *<val_1> <comp> <val_2> /control/execute <macro_file>*

- /control/strdoif *<str_1> <comp> <str_2> <shell_command>*
- /control/strif *<str_1> <comp> <str_2> <macro_file>*
  - *E.g. /control/getVal particleName /gun/particle*
    /control/strif {particleName} == proton myMacro.mac

- /control/doifBatch *<UI_command>*
- /control/ifBatch *<macro_file>*
- /control/doifInteractive *<UI_command>*
- /control/ifInteractive *<macro_file>*
  - *E.g. /control/ifInteractive vis.mac*

- /control/useDoublePrecision
  - Use double precision for printing out the current parameter value.