The RTS2 Protocol

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Remote Telescope System 2nd version (RTS2) is an open source project aimed at developing a software environment to control a fully robotic observatory. RTS2 consists of various components, which communicate via an ASCII based protocol. As the protocol was from the beginning designed as an observatory control system, it provides some unique features, which are hard to find in the other communication systems. These features include advanced synchronization mechanisms and strategies for setting variables. This presentation describes the protocol and its unique features. It also assesses protocol performance, and provides examples how the RTS2 library can be used to quickly build an observatory control system.

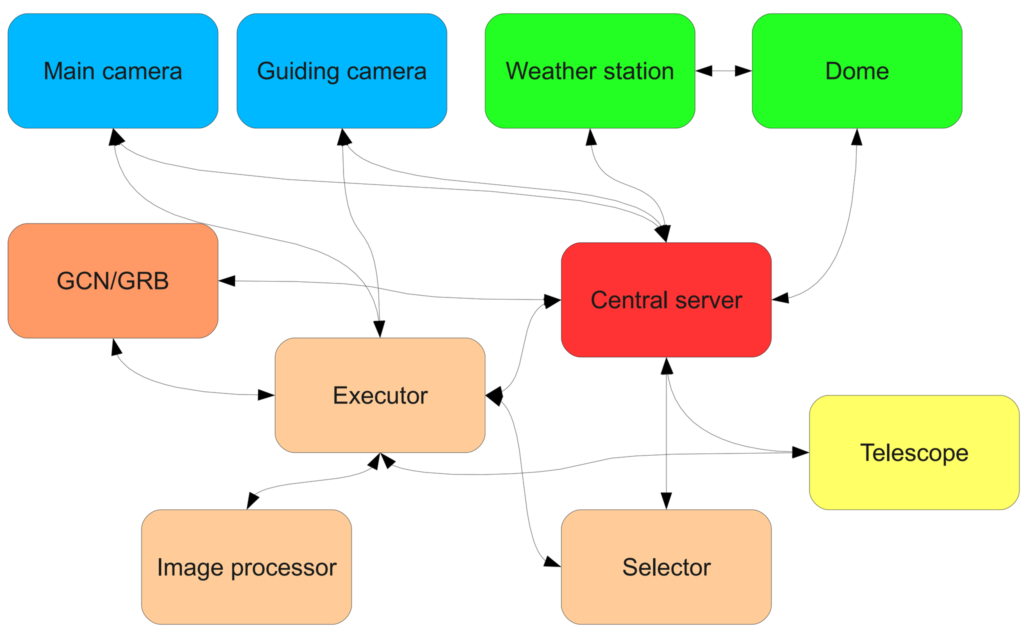
Introduction

Remote Telescope System development started in 2001 as a student project at the Charles University in Prague. The goal was to develop a system capable of operating a telescope devoted to follow-up observations of γ – ray bursts (GRBs). This task was later extended to a development of a system for a full control of the robotic observatory, with one of the observations targets being a quick follow–ups of the γ – ray burst optical transients.

From the early beginning RTS2 was designed as a plug–and–play system, capable to drive various instruments and to provide a common infrastructure for them. It is clear that this component system needs some communication layer. Initial investigation of the off–the–shelf communication libraries led to decision to develop an own layer on top of the TCP/IP protocol stack. After years of development this communication layer matured to a level that it easily supports requirements from new instruments and experiments. Due to its focus on observatory control it can be considered to be better observatory communication library then the off–the–shelf libraries available today.

Robotic observatory

Robotic observatory contains various devices. *RTS2* allows them to communicate with each other. It also provides various other services. Please see *Kubánek 2006* for full description of all *RTS2* functions. Following figure list *RTS2* components presents in usual setup and connection between them.



The protocol

Protocol uses ASCII sentences sent over TCP/IP. It design was inspired by *Simple Mail Transfer Protocol*. The sentences contains sentence type and parameters. Protocol allows full two way communication between observatory components.

RTS2 was designed with easy extensibility of the code in mind. Following features allows fast and easy expansion of the code with new drivers and functionalities.

Variables which are defined in single file. They are automatically registered in FITS file. Flags associated with variable specify when during the exposure cycle the variable value will be recorded.

States variables used for synchronization of operations carried on device.

Scripting language which automatically sequence command execution and enable end users to easily carry different observations.

Synchronization functions which allows various synchronization scenarios.

Following is step–by–step explanation of scenario used for telescope corrections synchronization:

1. Telescope driver receives correction from image processing process
2. Telescope driver sends to central daemon and all connected devices blocking mask, indicating that it is moving
3. Central daemon distributes moving mask to all connected devices. From now on the system will postpone all commands which required telescope to track the position.
4. Telescope driver sends query to central daemon, asking for its blocking state
5. Central daemon distribute query to all devices which might block telescope movement
6. Devices respond to central daemon. They previously received new blocking mask from telescope driver, so they will not start new exposure
7. Central daemon collect informations from the devices and send the resulting mask to telescope driver.
8. If telescope can move, algorithm continue with step 11.
9. Telescope waits for updates of device blocking state.
10. Once the blocking state update is received, algorithm continues with step 8.
11. Telescope starts moving.
12. If during moving any new exposure is tried, it is postponed, as system is not ready to receive it.
13. Telescope ends moving, sends blocking state without moving bit set to the central daemon.
14. Central daemon distributes blocking state updates to the device.
15. Devices receives blocking state update, If there is any queued exposure, the exposure is started.

References

RTS2 SourceForge site – *http://rts-2.sf.net*

Kubánek, P. et. al., *RTS2: a powerfull robotic observatory manager*
in SPIE 6274: Advanced Software and Control for Astronomy, 2006

Example

Here is an example code, showing implementation of the simple sensor device, which has one integer and one selection variable. The device is connected by serial port, so it provides a command line option to specify which serial port is used, with "/dev/ttyS0" being the default serial connection.

```
#include "../utils/rts2device.h"
#include "../utils/rts2connserial.h"

class Rts2DevSensorDummy:public Rts2Device
{
  private:
     Rts2ValueInteger *testInt;
     Rts2ValueDouble *testDouble;

     const char *serialDev;
     Rts2ConnSerial *serialConn;

  protected:
     virtual int processOption (int in_opt)
     {
       switch (in_opt)
       {
          case 'f':
            serialDev = optarg;
            break;
          default:
            return Rts2Device::processOption (in_opt);
       }
       return 0;
     }

     virtual int init ()
     {
       int ret;
       // first call init from parent class, as that will also parse
       // command line option
       ret = Rts2Device::init ();
       if (ret)
         return ret;
       serialConn = new Rts2ConnSerial (serialDev, this, BS9600, C8, NONE, 40);
       return serialConn->init ();
     }

     virtual int setValue (Rts2Value * old_value, Rts2Value * newValue)
     {
       if (old_value == testInt)
         return 0; // full version will write here to the device
       if (old_value == testDouble)
         return 0; // same as above
       return Rts2DevSensor::setValue (old_value, newValue);
     }

  public:
     Rts2DevSensorDummy (int in_argc, char **in_argv)
     :Rts2Device (in_argc, in_argv, "S1")
     {
       createValue (testInt, "TEST_INT", "test integer value",
         true, RTS2_VWHEN_RECORD_CHANGE, 0, false);
       createValue (testDouble, "TEST_DOUBLE", "test double value", true);

       addOption ('f', NULL, 1, "serial port used for device communication");

       serialDev = "/dev/ttyS0";
       serialConn = NULL;
     }
};

int main (int argc, char **argv)
{
  Rts2DevSensorDummy device = Rts2DevSensorDummy (argc, argv);
  return device.run ();
}
```

Supported devices

RTS2 have drivers for various devices which astronomers uses. Devices are integrated into an observatory environment using communication library which is part of the *RTS2*. New device drives can be easily coded. Devices from following manufactures are supported in the current RTS2 code base.

- CCD detectors
  Andor Technologies, Apogee, Finger Lake Instruments, SAO control board, SBIG, Starlight XPress
- Telescopes
  Losmandy Gemini, Meade LX200 and other LX200 variants, OpenTPL, Paramount by Software Bisque
- Focusers
  Finger Lake Instruments, OpenTPL, Optec, Robofocuser, Finger Lake Instruments
- Filter wheels
  Finger Lake Instruments, Optec, SBIG
- Photomultipliers
  Optec
- Domes
  Own design, OpenTPL
- Sensors and other devices
  Aerotech A3200 motion controller, Cryocoon cryogenic controller, Keyithley picoampermeters, MS257 monochromator, NewPort light source, Phytron stepper motor controller