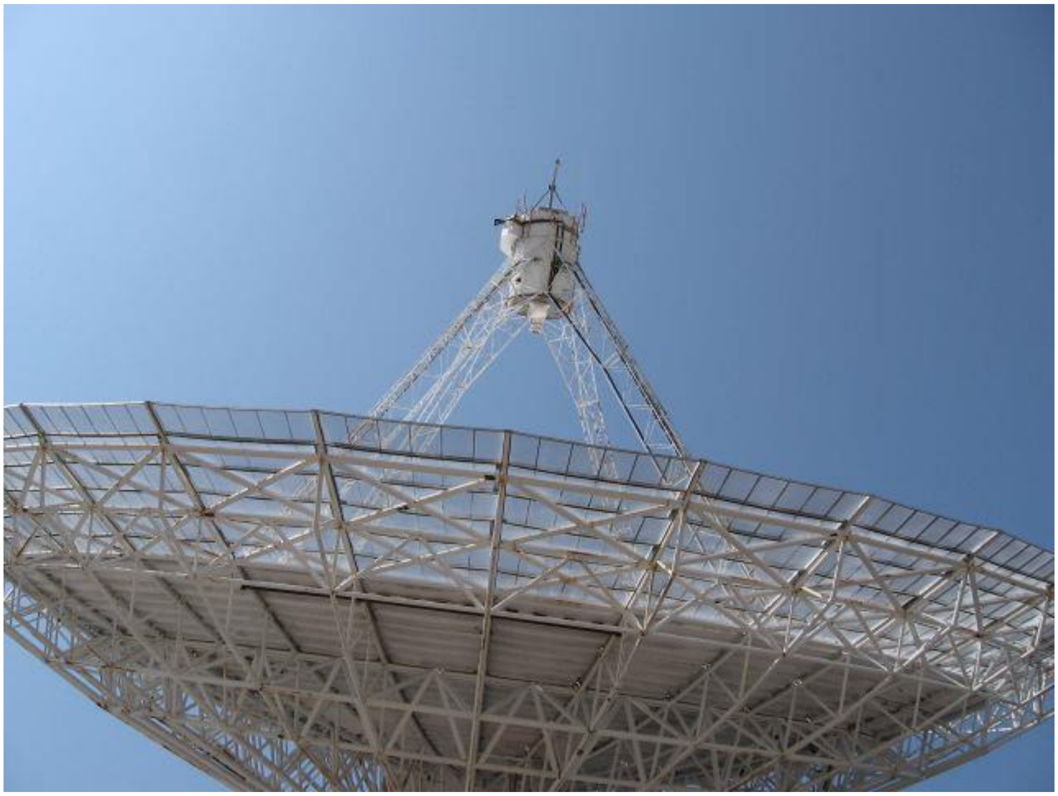
ENG 4350 6.0 FW16/17- Space Hardware

Lab P5 – Integrating high level subroutine/functions into the main program and debugging the software



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Contents

Purpose

The purpose of this report is to demonstrate the integration of all high-level functions into the main to perform an end-to-end test.

Fixes – Software/Code

The following functions have been altered for enhanced performance and compatibility with the rest of our main code.

- THETAN()

Customized the THETAN function such that it takes two parameters, the TLE epoch and the starting date of our tracking schedule. Inside the function we utilize an internal function in the DateAndTimeCalculations.c to calculated the Julian date at epoch.

Subsequently the header file was changed to include the extra input.

```
- double THETAN(double TLEepoch){
-       double num = TLEepoch;
-       num = TLEepoch/1000;
-       double year = num - frac(num);
-       double day = TLEepoch - year*1000;
-       double yearf = year + 2000;
-       double JDy = jdaty(yearf);
-       double JD = JDy + day -1;
-       double rads = THETAJ(JD);
+ double THETAN(double TLEepoch, double JDstart){
+       double JD;
+       JD = jdatep(TLEepoch);
+       double rads = THETAJ(JD, JDstart);
        return rads;
```

- THETAJ()

```
- double THETAJ (double JulianDate){
+ double THETAJ (double JulianDate, double JulianDateStart){
        double JDm;
-       if(JulianDate>=floor(JulianDate) + 0.5){JDm = floor(JulianDate) + 0.5;}
-       else{JDm = floor(JulianDate) - 0.5;}
-       double Du = JulianDate - 2451545.0;
+       if(JulianDateStart>=floor(JulianDateStart) + 0.5){JDm = floor(JulianDateStart) + 0.5;}
+       else{JDm = floor(JulianDateStart) - 0.5;}
+       double Du = JDm - 2451545.0;
        double Tu = Du / 36525.0;
        double GMST = 24110.54841 + 8640184.812866*Tu + 0.093104*Tu*Tu - 0.0000062*Tu*Tu*Tu;
        for (;GMST > 86400;){
```

The THETAJ function had to be changed to accommodate the tracking schedule start date as an input. In the if-statement the tracking date is used as the comparative, the rest of the code remains the same, but now the function returns the GMST angle in radians for the specific Julian date.

- Added link signal strength to the main()

The signal strength has been added to the AOS/LOS table where an array is created to hold the signal strength of each satellite in the table. The formatting of the table was altered so that it displays as specified in the Tracking Specifications and on the user console.

```
-
+     double ss[31];
      for(int j=1; j<32; j++){//Run through each satellite

          double currentTime;
@@ -377,7 +377,7 @@ int main(void){
-             double ss[31];
-             //ss[num] = linkstrength(rtPos->mag);
+
+             ss[num] = linkstrength(rtPos->mag);
              if (LA->elevation <= stn->az_el_lim.elmax && LA->elevation >= stn->az_el_lim.elmin && acquired == 0){//Go in to this loop if the
              satellite is acquired.
                  //If the satellite has already been acquired then don't add it again
                  NUM[num] = j;
@@ -418,10 +418,11 @@ int main(void){
      fprintf(filepoint, "Sat No.           Name                    AOS                     LOS                     Min. ExpectedLevel (dBm)\n");
      for(int i=0;i<num;i++){
          printf("%d    %s %s   ", NUM[i], NAME[i], jd2dat(AOS[i]));
-         printf("%s\n", jd2dat(LOS[i]));
+         printf("%s", jd2dat(LOS[i]));
+         printf("\t%f\n",ss[i]);
          fprintf(filepoint, "%d        %s   %s   ", NUM[i], NAME[i], jd2dat(AOS[i]));
          fprintf(filepoint, "%s", jd2dat(LOS[i]));
-     //  fprintf(filepoint,"%f\n",linkstrength(rtPos->mag));
+         fprintf(filepoint,"   %f\n",ss[i]);
      }
      fclose(filepoint);
      return 0;
```

Software Advancements

This section shows the advancements we made with the fixes in our code and confirmed with STK to approve.

AOS/LOS Data

Here is what the AOS/LOS table looks like with the expected signal strength:

Sat No.	Name	AOS	LOS	Min. ExpectedLevel (dBm)
0	GPS BIIR-2 (PRN 13)	2017-03-19 00:00:00	2017-03-19 00:59:59	-194.751455
2	GPS BIIR-4 (PRN 20)	2017-03-19 00:00:00	2017-03-19 00:59:59	-191.842836
3	GPS BIIR-5 (PRN 28)	2017-03-19 00:00:00	2017-03-19 00:59:59	-209.598671
4	GPS BIIR-6 (PRN 14)	2017-03-19 00:00:00	2017-03-19 00:59:59	-194.866402
7	GPS BIIR-9 (PRN 21)	2017-03-19 00:49:59	2017-03-19 00:59:59	-191.745841
11	GPS BIIR-13 (PRN 02)	2017-03-19 00:00:00	2017-03-19 00:59:59	-191.760244
12	GPS BIIRM-1 (PRN 17)	2017-03-19 00:00:00	2017-03-19 00:59:59	-204.384352
16	GPS BIIRM-5 (PRN 29)	2017-03-19 00:00:00	2017-03-19 00:59:59	-203.887205
19	GPS BIIF-1 (PRN 25)	2017-03-19 00:00:00	2017-03-19 00:59:59	-208.525202
20	GPS BIIF-2 (PRN 01)	2017-03-19 00:00:00	2017-03-19 00:59:59	-191.225996
22	GPS BIIF-4 (PRN 27)	2017-03-19 00:00:00	2017-03-19 00:59:59	-205.369155
23	GPS BIIF-5 (PRN 30)	2017-03-19 00:00:00	2017-03-19 00:59:59	-195.516778
24	GPS BIIF-6 (PRN 06)	2017-03-19 00:54:59	2017-03-19 00:59:59	-190.791992
25	GPS BIIF-7 (PRN 09)	2017-03-19 00:00:00	2017-03-19 00:59:59	-195.258373
27	GPS BIIF-9 (PRN 26)	2017-03-19 00:00:00	2017-03-19 00:59:59	-208.562454
29	GPS BIIF-11 (PRN 10)	2017-03-19 00:00:00	2017-03-19 00:59:59	-191.842144

Tracking Data

For the final roll, out of our software the Tracking Data table, as specified in 5.2 of Tracking Specifications lab manual. After the AOS/LOS table is calculated we:

1. Prompt the user to select a satellite to track from the AOS/LOS table
2. Use the satellite TLE parameters to calculate
    a. sat_ECI() to find the satellite ECI position and velocity

b. sat_ECF() to find the satellite ECF position and velocity
c. station_ECF() to find the station position
d. range_ECF2topo() to find the position and velocity
e. Range_topo2look_angles() to find the position and velocity angles and range from the topocentric coordinate system.

```diff
@@ -439,11 +439,17 @@ int main(void){
     fflush(stdout);
     scanf("%d", &satNum);
     Satellite sat = sats[satNum+1];
+    FILE *xp;
+    xp = fopen("TrackingData.txt", "w+");
     printf("\n--------------------------------------------------------------------------------------------------------------------
\n");
     printf("UTC\t\t\tAZ\t\tEL\t\tAZ-vel\t\tEL-vel\t\tRange\t\tRange-Rate\t\tDoppler\t\tLevel\n");
     printf("\t\t\tdeg\t\tdeg\t\tdeg/sec\t\tdeg/sec\t\tkm\t\tkm/sec\t\t\tkHz\t\tdbm\n");
     printf("--------------------------------------------------------------------------------------------------------------------\n");

+    fprintf
(xp,"\n--------------------------------------------------------------------------------------------------------------------\n");
+    fprintf(xp,"UTC\t\t\tAZ\t\tEL\t\tAZ-vel\t\tEL-vel\t\tRange\t\tRange-Rate\t\tDoppler\t\tLevel\n");
+    fprintf(xp,"\t\t\tdeg\t\tdeg\t\tdeg/sec\t\tdeg/sec\t\tkm\t\tkm/sec\t\t\tkHz\t\tdbm\n");
+    fprintf(xp,"--------------------------------------------------------------------------------------------------------------------
\n");

     double currentTime;
      currentTime = JulianDateStart;
@@ -491,9 +497,8 @@ int main(void){
         ss[num] = linkstrength(rtPos->mag);

         printf("%s\t%f\t%f\t%f\t%f\t%f\t%f\t\t\t\t%f\n", jd2dat(currentTime),LA->azimuth,LA->elevation,LA->azimuth_velocity,LA->elevation_velocity,sqrt(rtPos->x*rtPos->x+rtPos->y*rtPos->y+rtPos->z*rtPos->z),sqrt(rtVel->x*rtVel->x+rtVel->y*rtVel->y+rtVel->z*rtVel->z),linkstrength(rtPos->mag));
-
-
+        fprintf(xp,"%s\t%f\t%f\t%f\t%f\t%f\t%f\t\t\t\t%f\n", jd2dat(currentTime),LA->azimuth,LA->elevation,LA->azimuth_velocity,LA->elevation_velocity,sqrt(rtPos->x*rtPos->x+rtPos->y*rtPos->y+rtPos->z*rtPos->z),sqrt(rtVel->x*rtVel->x+rtVel->y*rtVel->y+rtVel->z*rtVel->z),linkstrength(rtPos->mag));
     }
-
+    fclose(fp);
     return 0;
 }
```

Here is what it looks like on the console. Simultaneously it is printed to a file named TrackingData.txt

```
Enter the satellite number you would like to track from the table (values in the first column): 0

--------------------------------------------------------------------------------------------------------------------------
UTC                  AZ          EL           AZ-vel      EL-vel      Range           Range-Rate       Doppler     Level
                     deg         deg          deg/sec     deg/sec     km              km/sec           kHz         dbm
--------------------------------------------------------------------------------------------------------------------------
2017-03-19 00:00:00  64.726728   -22.897671   -0.000077   0.000122    25275.710905    3.159979                     -195.507249
2017-03-19 00:04:59  63.049901   -20.904136   -0.000074   0.000123    25254.013698    3.168479                     -195.490073
2017-03-19 00:09:59  61.425865   -18.877012   -0.000071   0.000123    25231.991827    3.175170                     -195.472625
2017-03-19 00:14:59  59.845971   -16.822333   -0.000069   0.000123    25209.710261    3.179985                     -195.454956
2017-03-19 00:19:59  58.301721   -14.745881   -0.000067   0.000123    25187.235078    3.182878                     -195.437117
2017-03-19 00:24:59  56.784793   -12.653233   -0.000066   0.000123    25164.633298    3.183824                     -195.419162
2017-03-19 00:29:59  55.287049   -10.549811   -0.000065   0.000122    25141.972669    3.182816                     -195.401144
2017-03-19 00:34:59  53.800529   -8.440934    -0.000065   0.000120    25119.321487    3.179866                     -195.383117
2017-03-19 00:39:59  52.317447   -6.331862    -0.000065   0.000118    25096.748393    3.175008                     -195.365137
2017-03-19 00:44:59  50.830177   -4.227848    -0.000065   0.000115    25074.322160    3.168297                     -195.347257
2017-03-19 00:49:59  49.331244   -2.134176    -0.000066   0.000111    25052.111478    3.159804                     -195.329533
2017-03-19 00:54:59  47.813313   -0.056207    -0.000067   0.000107    25030.184737    3.149623                     -195.312021
2017-03-19 00:59:59  46.269192   2.000580     -0.000069   0.000101    25008.609817    3.137867                     -195.294774
```

Conclusion

Our software has demonstrated the integration of all the functions required to track the GNSS satellites.