EGRE 246 Advanced Engineering Programming Using C++
Homework #8 – State Machines – NMEA GPS sentence parsing (part 2)

This homework must be your own (individual) work as defined in the course syllabus and discussed in class.

Your solution for homework #7 parses NMEA GPS sentences, determines their type, and checks the checksum to insure that the message was received correctly. It also stores all of the characters in the message data into a character buffer.

In this homework, you will add to your solution for homework #7 the capability to parse the data from the messages and display it on the screen. The table below shows the information from the GPS messages that must be displayed.

Data Item	Data Format	Example
UTC time	hhmmss.sss	1550006.000
Date	dd/mm/yyyy	14/10/2014
Latitude	±dd***d*** mm.mmmm**'**	37d 32.7239'
Longitude	±dd***d*** mm.mmmm**'**	-77d 26.9956'
Altitude	mm.mm***M***	89.1M
Speed	ss.ss ***knots***	0.00 knots
Course	dd.dd***d***	80.30d
GPS Fix type and Mode	No fix, 2D, 3D	3D
Satellite count	cc	07
PDOP	pp.p	3.2
HDOP	hh.h	50.0
VDOP	vv.v	2.7

Note that the format for display of the data shown above may be different than the format that the data is transmitted in the NMEA GPS sentences. Your program must transform the data as necessary in order to display it correctly. The data items must be updated and displayed (i.e., written to the screen) each time a complete and correct message is received.

Also note that not all data items are included in just one message. Thus, it will take a sequence of message, of each of the four types, to properly fill out all of the data items.

The latitude in the NMEA GPS sentences is transmitted in N or S directions and the longitude is transmitted in E or W directions. For display, the latitude and longitude must be translated into ± format – S latitude and W longitude are negative (i.e., -) and N and E are positive.

The example below shows the data output that is displayed after the final message in the file *gps8.log* is read:

```
UTC time:155006.000
Date:14/10/2014

Latitude:37d 32.7239'
Longitude:-77d 26.9956'
Altitude:89.1M
Speed:0.00 knots, Course:80.30 degrees, true

3D fix
Satellite count:5
PDOP:3.2
HDOP:1.7
VDOP:2.7
```

The data in the NMEA GPS sentences is contained in comma-separated fields. The format and values of the data fields for each message type is shown in the attached pages from the GPS unit's data sheet. While the number of fields in each message type and their meanings are fixed, depending on the state of the GPS receiver, whether or not they actually contain data is variable. For example, with a valid GPS fix, a GPGGA message may look like this one:

```
$GPGGA,155002.000,3732.7239,N,07726.9956,W,1,05,1.7,89.1,M,-33.6,M,,0000*58
```

But without a GPS fix, a GPGGA message may look like this one:

```
$GPGGA,190326.054,,,,,0,00,50.0,,M,0.0,M,,0000*43
```

Your program must correctly parse each NMEA GPS sentence regardless of whether or not any given field is empty or contains data.

When a given data item is contained in more than one message type, such as latitude and longitude, it must be parsed from all messages in which it is contained.

For this homework, submit a zip file with **ALL** of your source files. Be sure to include a Makefile that compiles your solution.

SOFTWARE COMMAND

NMEA Output Command

GGA - Global Positioning System Fixed Data

Note – Fields marked in italic *red* apply only to NMEA version 2.3 (and later) in this NMEA message description

Table B-2 contains the values for the following example:

$GPGGA,161229.487,3723.2475,N,12158.3416,W,1,07,1.0,9.0,M,-34.2,M,,0000*18

Table B-2 GGA Data Format

Name	Example	Units	Description
Message ID	$GPGGA		GGA protocol header
UTC Time	161229.487		hhmmss.sss
Latitude	3723.2475		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12158.3416		dddmm.mmmm
E/W Indicator	W		E=east or W=west
Position Fix Indicator	1		See Table B-3
Satellites Used	07		Range 0 to 12
HDOP	1.0		Horizontal Dilution of Precision
MSL Altitude	9.0	meters	
Units	M	meters	
Geoid Separation[1]	-34.2	meters	Geoid-to-ellipsoid separation. Ellipsoid altitude=MSL Altitude + Geoid Separation
Units	M	meters	
Age of Diff. Corr.		second	Null fields when DGPS is not used
Diff. Ref. Station ID	0000		
Checksum	*18		
<CR><LF>			End of message termination

Table B-3 Position Fix Indicator

Value	Description
0	Fix not available or invalid
1	GPS SPS Mode, fix valid
2	Differential GPS, SPS Mode , fix valid
3	Not supported
6	*Dead Reckoning Mode, fix valid*

Note:

A valid status is derived from all the parameters set in the software. This includes the minimum

GSA - GNSS DOP and Active Satellites

Table B-5 contains the values for the following example:

$GPGSA,A,3,07,02,26,27,09,04,15,,,,,,1.8,1.0,1.5*33

Table B-5 GSA Data Format

Name	Example	Units	Description
Message ID	$GPGSA		GSA protocol header
Mode 1	A		See Table B-6
Mode 2	3		See Table B-7
Satellite Used[1]	07		Sv on Channel 1
Satellite Used[1]	02		Sv on Channel 2
…..			
Satellite Used[1]			Sv on Channel 12
PDOP[2]	1.8		Position dilution of Precision
HDOP[2]	1.0		Horizontal dilution of Precision
VDOP[2]	1.5		Vertical dilution of Precision
Checksum	*33		
<CR><LF>			End of message termination

1. Satellite used in solution.
2. Maximum DOP value reported is 50. When 50 is reported, the actual DOP may be much larger.

Table B-6 Mode1

Value	Description
M	Manual-forced to operate in 2D or 3D mode
A	2Dautomatic-allowed to automatically switch 2

Table B-7 Mode 2

Value	Description
1	Fix Not Available
2	2D (<4 SVs used)
3	3D (>3 SVs used)

GSV - GNSS Satellites in View

Table B-8 contains the values for the following example:

$GPGSV,2,1,07,07,79,048,42,02,51,062,43,26,36,256,42,27,27,138,42*71

$GPGSV,2,2,07,09,23,313,42,04,19,159,41,15,12,041,42*41

Table B-8 GSV Data Format

Name	Example	Units	Description
Message ID	$GPGSV		GSV protocol header
Number of Messages[1]	2		Range 1 to 3
Message Number[1]	1		Range 1 to 3
Satellites in View[1]	07		
Satellite ID	07		Channel 1(Range 1 to 32)
Elevation	79	degrees	Channel 1(Maximum90)
Azimuth	048	degrees	Channel 1(True, Range 0 to 359)
SNR(C/No)	42	dBHz	Range 0 to 99,null when not tracking
…….			…….
Satellite ID	27		Channel 4 (Range 1 to 32)
Elevation	27	Degrees	Channel 4(Maximum90)
Azimuth	138	Degrees	Channel 4(True, Range 0 to 359)
SNR(C/No)	42	dBHz	Range 0 to 99,null when not tracking
Checksum	*71		
<CR><LF>			End of message termination

1. Depending on the number of satellites tracked, multiple messages of GSV data may be required. In some software versions, the maximum number of satellites reported as visible is limited to 12, even though more may be visible.

RMC - Recommended Minimum Specific GNSS Data

Note – Fields marked in italic *red* apply only to NMEA version 2.3 (and later) in this NMEA message description

Table B-9 contains the values for the following example:

$GPRMC,161229.487,A,3723.2475,N,12158.3416,W,0.13,309.62,120598,,,A*10

Table B-9 RMC Data Format

Name	Example	Units	Description
Message ID	$GPRMC		RMC protocol header
UTC Time	161229.487		hhmmss.sss
Status[1]	A		A=data valid or V=data not valid
Latitude	3723.2475		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12158.3416		dddmm.mmmm
E/W Indicator	W		E=east or W=west
Speed Over Ground	0.13	knots	
Course Over Ground	309.62	degrees	True
Date	120598		ddmmyy
Magnetic Variation[2]		degrees	E=east or W=west
East/West Indicator[2]	E		E=east
Mode	*A*		*A=Autonomous, D=DGPS,* *E=DR* *N=Output Data Not Valid* *R= Coarse Position[3]* *S=Simulator*
Checksum	*10		
<CR><LF>			End of message termination

1. A valid status is derived from all the parameters set in the software. This includes the minimum number of satellites required, any DOP mask setting, presence of DGPS corrections, etc. If the default or current software setting requires that a factor is met, then if that factor is not met the solution will be marked as invalid.
2. SiRF Technology Inc. does not support magnetic declination. All “course over ground” data are geodetic WGS84 directions relative to true North.
3. Position was calculated based on one or more of the SVs having their states derived from almanac parameters, as opposed to ephemerides.