Coordinate Systems and Page Layout in Nightingale

Nightingale Technical Note #11

Don Byrd, July 2001; rev. early February 2017

Units, Absolute and Relative

Nightingale deals with several types of coordinates expressed in several different units; some of the units have absolute sizes and some are relative to something. Here are the most important units. (Abs = absolute size, Stf = relative to staff size, Mag = relative to screen magnification)

	Unit	*Definition*
Abs	DDIST	1/16th point = 1/1152nd inch (this is based on the assumption that a point is exactly 1/72nd inch, which is not quite the traditional value)
Mag	pixel	Just what it sounds like
Stf	STDIST	1/8 distance between staff lines

To oversimplify slightly, Nightingale keeps coordinates of musical symbols relative to their measure, staff, or system in terms of either DDISTs or STDISTs. Almost all coordinates in the object list are in DDISTs. For example, coordinates of systems are stored as DDISTs relative to the page. For details, see the section Relative-Origin Coordinates, below.

In addition, Nightingale occasionally uses these units:

Abs	point	1/72nd inch
Stf	QDIST	1/4 distance between staff lines = 2 STDIST
Stf	FIdealSpace	1/10 STDIST

Nightingale keeps the page size and margins in points. It uses QDIST instead of STDIST to get twice the range (though at half the resolution), and it uses FIdealSpace, a.k.a. Fractional STDIST, to compute horizontal spacing more accurately.

A Nightingale score can contain staves of two different sizes; if it does, the absolute equivalents of STDIST and units derived from it will vary from staff to staff. (Unfortunately, as of this writing, Nightingale's own user interface doesn't support creating scores with different size staves. The ancient utility NightStaffSizer does, but I doubt if it runs on OS X except via SheepShaver.)

A Bit About Nightingale's "Object List" Data Structure

Nightingale's main data structure is called the *object list;* its organization mirrors the two-dimensional layout of the score. An object list is a doubly-linked list of *objects.* There are about 20 types of objects, including SYNC, GRSYNC , SYSTEM, STAFF, CONNECT, MEASURE, CLEF, KEYSIG, TIMESIG, BEAMSET, SLUR, TUPLET, TEMPO, etc. Each object can—and most do—have attached to it a singly-linked list of *subobjects* that logically belong together and that are normally more-or-less vertically aligned, though they do not have to be. The subobjects are what you'd expect (other than for a couple of objects with mysterious names), for example:

Object	*Subobjects*
SYNC	notes and rests with same logical onset time
GRSYNC	grace notes with same logical onset time
STAFF	staves in a system
CONNECT	braces and brackets grouping staves together
MEASURE	measures in a system (one per staff)
CLEF	clefs with same logical onset time (max. one per staff)
KEYSIG	key signatures in a system (max. one per staff)
TIMESIG	time signatures in a system (max. one per staff)
BEAMSET	notes/rests/chords belonging to the set of beams

As you might expect, notes are the most complex symbols; accordingly, SYNC subobjects are the most complex subobjects. For much more information, see other Nightingale Tech Notes.

Relative-Origin Coordinates

In conventional music notation, roughly speaking, systems contains staves; staves contain measures; measures contain the “ordinary” graphical symbols of music notation; and a few symbols are subordinate to and positioned with respect to “ordinary” symbols. Relative coordinates in Nightingale’s data structures reflect this heirarchic organization pretty directly, and some things have several levels of “relativeness.”

1a. Both x and y coordinates of “note modifiers” (articulation marks, fingerings, fermatas, etc.) are relative to the subobjects (notes or rests) they’re attached to.

1a. Similarly, the x coordinates of Graphic objects—usually character strings—as well as those of dynamics, slurs/ties, tuplets, and octave signs are relative to the *subobjects* (usually notes or rests) they’re attached to, but their y coordinates are relative to the *objects*. Graphics and dynamics other than hairpins have only one attachment point; the others have both left and right attachment points.

2. For objects and subobjects representing most ordinary symbols (clef, key signature, time signature, note, grace note, rest, etc.), the x coordinate is relative to the Measure object’s <xd>; y is relative to the Measure subobject’s <measureTop>. Using the Measure object rather than individual subobjects for x-position works because Nightingale requires all subobjects of a given Measure to have the same left-end position, i.e., it requires that barlines always align on all staves.

3. The coordinates of Measures are relative to the Staffs they’re in. Specifically, the Measure object’s <xd> is relative to its Staff’s <staffLeft>. Measures don’t have stored y-positions: Nightingale uses the Staff’s y-position (I think).

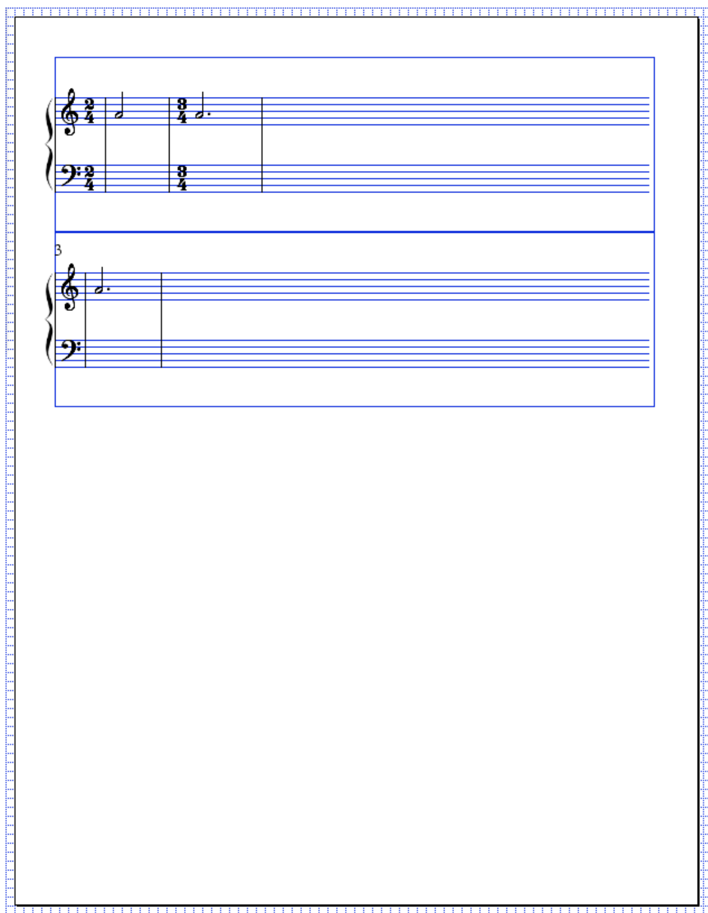
4. The coordinates of Staffs are relative to the Systems they’re in. Specifically, a Staff subobject’s top/left/right are relative to the System’s xd and yd. The xd and yd of the Staff object are ignored (I think).

5. The coordinates of Systems are relative to the Page they’re on. This is important for screen display because Nightingale can show, in an arbitrary rectangular grid, any number of pages simultaneously. However, to simplify the discussion below, we’ll assume the Page origin is (0, 0). (For printing, the effective Page origin is always (0, 0).)

Screen Coordinates. Nightingale can display many pages at once, The above rules describe how to convert coordinates of anything into coordinates relative to the page, but, for drawing on the screen, those still aren't absolute coordinates, i.e., coordinates in QuickDraw's terms. QuickDraw—the old Macintosh graphics package that Nightingale is unfortunately still tied to—has 16-bit integer coordinates, with both x and y ranging from -32767 to +32768. Nightingale thinks in terms of an array of pages (sometimes called "sheets" in the code and comments). The upper-left corner of the upper-left page in the array is at a position that is specified in the CNFG resource, but it's normally (–24000, –24000).

Coordinate System Demo

The "CoordinateSystemsDemo" score is an example of Nightingale coordinates in action. Here it is as displayed by Nightingale. (Show Invisibles is turned on; otherwise, the barline at the beginning of each system wouldn't be shown.)



Full Debug listing of the "CoordinateSystemsDemo" object list

Here's a listing of the complete object list of CoordinateSystemsDemo, produced by Nightingale's Debug command. All units are DDISTs, where one DDIST = 1/16th point = 1/1152nd inch. NB: In each case, names on the left side of equals signs ("staffLeft", "staffTop ", etc.) are effectively the symbol's x and y origin.

Rule 4 defines the positions of the staves in the first system (Link 4). For staff 1:

staffLeft	=	systemLeft	+	Staff subobject left		
576	=	576	+	0		
staffTop	=	systemTop	+	Staff subobject top		
1152	=	576	+	576		

If the page in question is currently the first (top-left) page on the screen, then ordinarily,

The screen coordinates of the point (staffLeft, staffTop) are

–24000+576 = –23424, and

-24000+1152 = -22848

Rule 3 applies to the measureLeft and measureTop of the Measure (Link 9), which, given the above, are found for staff 1 via:

measureLeft	=	staffLeft	+	Measure object xd
2208	=	576	+	1632
measureTop	=	staffTop		
1152	=	1152		

And Rule 2 applies to the SYNC subobject (a note) on staff 1 in the 2nd measure (Link 13), for which:

xd	=	measureLeft	+	object xd	+	subobject xd
2592	=	2208	+	384	+	0
yd	=	measureTop	+	object yd	+	subobject yd
1392	=	1152	+	240	+	0

In the listing below, a line beginning with "L" followed by a number is an object; the indented lines following are its subobjects.

```
DEBUG 'M': FULL/CHK: headL=1 tailL=23 (Obj flags: SelVisSoftValidTwkd)
 L 1 xd=0 yd=0 HEAD ..S.. oRect.l=p0 sr=1 mrRect=p36,36,774,567 nst=2
nsys=2 n=2
     partL=1 next=2 firstst=-2 lastst=-2 velo=0 transp=0 name=DUMMY
     partL=2 next=0 firstst=1 lastst=2 velo=0 transp=0 name=Unnamed
 L 2 xd=0 yd=0 PAGE .VS.. oRect.l=p0 p#=0
 L 3 xd=576 yd=576 SYSTEM .VS.. oRect.l=p18 sRect=d576,576,3072,9168 s#=1
 L 4 xd=0 yd=0 STAFF .VS.. oRect.l=p0 n=2
     st=1 top,left,ht,rt=d576,0,384,8496 lines=5 fontSz=24 .V TS=1,4/4
     st=2 top,left,ht,rt=d1536,0,384,8496 lines=5 fontSz=24 .V TS=1,4/4
 L 5 xd=80 yd=0 CONNECT .VS.. oRect.l=p0 n=2
     xd=0 lev=0 type=1 stfA=-2 stfB=-2 firstPart=-2 last=-2 .
     xd=-168 lev=7 type=3 stfA=1 stfB=2 firstPart=2 last=0 .
 L 6 xd=96 yd=0 CLEF .VSV. oRect.l=p21 . n=2
     st=1 xd=0 clef=3 .V.
     st=2 xd=0 clef=10 .V.
 L 7 xd=432 yd=0 KEYSIG .VSV. oRect.l=p32 . n=2
```

```
     st=1 xd=0 ... nKSItems=0 nNatItems=0
     st=2 xd=0 ... nKSItems=0 nNatItems=0
 L 8 xd=432 yd=0 TIMESIG .VSV. oRect.l=p32 . n=2
     st=1 xd=0 type=1,2/4 .V.
     st=2 xd=0 type=1,2/4 .V.
 L 9 xd=720 yd=0 MEASURE ..SV. oRect.l=p39 Box=p18,41,96,69 s%=100 TS=0 n=2
     st=1 m#=0 barTp=1 cnst=2 clf=3 mR=d0,0,1536,912 ...M. nKS=0 TS=1,2/4
     st=2 m#=0 barTp=1 cnst=0 clf=10 mR=d960,0,2496,912 ...MC nKS=0
TS=1,2/4
 L10 xd=144 yd=0 SYNC .V.V. oRect.l=p44 TS=0 LT=0 n=1
     st=1 v=1 xd=0 yd=240 ystm=-96 yqpit=-10 ldur=3 .s=0 ac=0 onV=75
.V.........
 L11 xd=1632 yd=0 MEASURE .V.V. oRect.l=p67 Box=p18,69,96,110 s%=100 TS=960
n=2
     st=1 m#=1 barTp=1 cnst=2 clf=3 mR=d0,0,1536,1320 .V.M. nKS=0 TS=1,2/4
     st=2 m#=1 barTp=1 cnst=0 clf=10 mR=d960,0,2496,1320 .V.MC nKS=0
TS=1,2/4
{L12 xd=120 yd=0 TIMESIG SV.V. oRect.l=p73 M n=2
     st=1 xd=0 type=1,3/4 SV.
     st=2 xd=0 type=1,3/4 .V.
}L13 xd=384 yd=0 SYNC .V.V. oRect.l=p80 TS=0 LT=0 n=1
     st=1 v=1 xd=0 yd=240 ystm=-96 yqpit=-10 ldur=3 .s=1 ac=0 onV=75
.V.........
 L14 xd=2952 yd=0 MEASURE .V.V. oRect.l=p108 Box=p18,110,96,283 s%=100
TS=2400 n=2
     st=1 m#=2 barTp=1 cnst=2 clf=3 mR=d0,0,1536,5544 .V.M. nKS=0 TS=1,3/4
     st=2 m#=2 barTp=1 cnst=0 clf=10 mR=d960,0,2496,5544 .V.MC nKS=0
TS=1,3/4
 L15 xd=576 yd=3072 SYSTEM .VS.. oRect.l=p18 sRect=d3072,576,5568,9168 s#=2
 L16 xd=0 yd=0 STAFF .VS.. oRect.l=p0 n=2
     st=1 top,left,ht,rt=d576,0,384,8496 lines=5 fontSz=24 .V TS=1,3/4
     st=2 top,left,ht,rt=d1536,0,384,8496 lines=5 fontSz=24 .V TS=1,3/4
 L17 xd=80 yd=0 CONNECT .VS.. oRect.l=p0 n=2
     xd=0 lev=0 type=1 stfA=-2 stfB=-2 firstPart=-2 last=-2 .
     xd=-168 lev=7 type=3 stfA=1 stfB=2 firstPart=2 last=0 .
 L18 xd=96 yd=0 CLEF .VSV. oRect.l=p21 . n=2
     st=1 xd=0 clef=3 .V.
     st=2 xd=0 clef=10 .V.
 L19 xd=432 yd=0 KEYSIG .VSV. oRect.l=p32 . n=2
     st=1 xd=0 ... nKSItems=0 nNatItems=0
     st=2 xd=0 ... nKSItems=0 nNatItems=0
 L20 xd=432 yd=0 MEASURE ..SV. oRect.l=p30 Box=p96,32,174,65 s%=100 TS=2400
n=2
     st=1 m#=2 barTp=1 cnst=2 clf=3 mR=d0,0,1536,1080 ...M. nKS=0 TS=1,3/4
     st=2 m#=2 barTp=1 cnst=0 clf=10 mR=d960,0,2496,1080 ...MC nKS=0
TS=1,3/4
 L21 xd=144 yd=0 SYNC .V.V. oRect.l=p35 TS=0 LT=0 n=1
```

```
     st=1 v=1 xd=0 yd=240 ystm=-96 yqpit=-10 ldur=3 .s=1 ac=0 onV=75
.V.........
 L22 xd=1512 yd=0 MEASURE .V.V. oRect.l=p63 Box=p96,65,174,283 s%=100
TS=3840 n=2
     st=1 m#=3 barTp=1 cnst=2 clf=3 mR=d0,0,1536,6984 .V.M. nKS=0 TS=1,3/4
     st=2 m#=3 barTp=1 cnst=0 clf=10 mR=d960,0,2496,6984 .V.MC nKS=0
TS=1,3/4
 L23 xd=0 yd=0 TAIL ..S.. oRect.l=p0
```