Parsing the Object Table

The object table contains offsets to all of the object's various data segments and also determines the interrelation of those segments. When considering creating or visualizing a large, multi-piece object, it is important to know which blocks position each individual piece, which pieces are part of a larger structure, and which affect the model as a whole. All of this can be gleaned from the basic structure of the object table.

Each table entry consists of six words, five of which define file offsets.

The first two words are used to dictate what kind of data is expected and where in the file it is located. The other four offsets point to other entries in the object table and are used for ordering the table.

There are two ways to link entries. **Child** entries share all of the attributes of their parents. Display lists are almost always children of other commands, adopting their position from parent position commands, the distance they are rendered at from distance commands, etc. By creating a series of parent/child entries, many different attributes can be assigned to a part of the model.

The **next** entry is the next table entry that has the same parent as the current command. The next entry does not share the attributes of the current entry, but still shares those of its own parents. All next and previous entries have the attributes of their parents but don't share attributes with each other. If there is more than one model for an object, like a high-resolution model when nearby and a lower-resolution model when at a distance, the near model's command will have a **next** entry set to the far model.

To better illustrate the connections between each command, some examples use a simple format giving the type of data, the offset of the object table entry, and brackets that reflect which commands follow and are children of that entry.

Offset	Type	Data Offset	Parent Offset	Next Entry	Previous Entry	Child Offset
0x100	00020000	05000148	00000000	00000000	00000000	05000118
0x118	00180000	05000420	05000100	05000130	00000000	00000000
0x130	00180000	05000500	05000100	00000000	05000118	00000000

02:100 denotes a table entry at offset 0x100 in the file. The command type is 02, which sets the position of a model part. It's first child entry is at 0x118, which is the next command. This is an 18 display list, and because it is a child of 02:100 it appears in brackets next to it. The parent offset is set to 0x100, it has no children of its own, and it is followed by another entry at 0x130. This is also a 18 display list, and it has the same parent as the previous entry at 0x118. It is also a child of 02:100 so it appears in brackets, but because it has no relation to 18:118 it is placed one line down.

Being children of 02:100, both 18:118 and 18:130 will adopt the position data set by 02:100. Technically the parts are rendered separately and moved to the position given in 02:100, but functionally it is as if every point in both of the display lists has had the position's x, y, and z values added to them. Neither 18 commands share any information with each other. If one of these had children, ie:

```
02:100    {0A:118   {18:130}
          18:148}
```

18:130 would be affected by 0A:118 and 02:100, since it is a child of both. However, 18:148 is only a child of 02:100, so it receives the position data but not the affects of either 0A:118 or 18:130. Both of those commands are outside of 18:148's scope.

Note though that parent's receive nothing from children. 02:100 in both examples receives no attributes from any of its children. In the second example, 0A:118 adopts the position of its parent, but the display list is beyond its own scope. Effects only compound from left to right.

Precedence becomes increasingly important in larger models. In guards and other large, multi-segmented models each piece of the model will be formed with one or more display lists and positioned relative to the rest of the model using one or more position commands. For instance, a hand is positioned to touch a forearm, the hand and forearm positioned to touch the triceps, and the whole arm is positioned on the chest, which is positioned above the legs to form the actual body.

```
01:B8     {02:D0    {02:3B8   {02:5B0   {02:5C8   {02:5E0   {0A:5F8   {18:610}}

                                                  0A:628    {08:640   {18:658}

                                                            08:670    {18:688}}}

                                        0A:6A0    {08:6B8   {18:6D0}

                                                  08:6E8    {18:700}}
```

All of this code is used to render the left arm of Brosnan's tuxedo. 18:610 is the character's left hand. 18:658 and 18:688 render their left forearm, using the 08 commands to indicate at what distance each should be used. The 18:6D0 and 18:700 also trigger at specific distances and are used to render the upper arm.

Every point in 18:610 is moved a total of five times; 02:D0, 02:3B8, 02:5B0, 02:5C8, and 02:5E0 all affect it's final position. 18:658 and 18:688 are only moved four times since 02:5E0 is outside their scope. 18:6D0 and 18:700 are only moved three times total, 02:5C8 and 02:5E0 both being out of their scope.

To determine exactly what commands influence a certain table entry is as simple as gathering a list of all its parents. For instance, if a full object table isn't handy and you need to know all the position modifications needed to render the display list in command 18:700, you can retrieve its parent's offset, then that parent's offset, etc., until finally the first entry is reached that lacks one. All the commands that influence 18:700 are:

08:6E8, 0A:6A0, 02:5B0, 02:3B8, 02:D0, 01:B8.

Simple Display Lists: Position Translation

Display lists render each of the parts of an object. All display list types consist of a table of points in the model as well as a list of display commands sent to the RDP. An example of a basic display list is the type 04 command, broken down here.

The mapping commands are numerous and complex, but for these purposes discussing them isn't important. Instead, a brief look at point tables is in order. A point table is constructed of many point structs, as seen here:

#	X Position	Y Position	Z Position	Reserved	S Image Pin	T Image Pin	RGBA Color
0	0020	FF96	0050	0000	0104	0099	676767FF
1	FFE0	FF96	0050	0000	00D5	0097	676767FF
2	FFE0	FF86	003B	0000	00D6	00A7	676767FF
3	0020	FF86	003B	0000	0104	00A9	676767FF
4	0020	0000	0000	0000	0106	00D4	676767FF
5	FFE0	0000	0000	0000	00D8	00D2	676767FF

Given above is a list of six points which would be used by the display list to render an object. The x, y, and z positions are used to produce the model itself. The s and t pins are used for alignment when image mapping, and a red/green/blue/alpha quad affects the resulting color of the generated point. The reserved short value is not used in basic display lists. For the rest of the document, only the three position values will be considered.

Each display list is rendered independently of each other but other commands in the object table can change the way in which rendering occurs. For instance, 08 commands only allow the display list to be rendered at certain distances, 12 commands can be used to select what kind of mapping is used, etc.

A part can be repositioned when one of the position commands is used. Each point within a subsequent child display list is offset by the given x, y, and z values, moving the whole part to a new location. The most common of these are type 02 commands.

For our purposes, the only parts of these position commands that will be considered are the three position values. The ordering and linkage values are used predominately by animation routines to select particular parts and manipulate them. The position values are always important though, since it is these that will be used to offset the point information in the child display list.

To apply the change, the given offsets are added to every position in its child point tables. This requires first converting them from floating-point notation into their decimal equivalents, then adding the values to each point in the table.

X modification	00000000	+0.
Y Modification	C1AA6670	-21.30
Z Modification	C21484ED	-37.13

#	X Original	Y Original	Z Original	X Moved	Y Moved	Z Moved
0	32	-106	80	32	-127.3	42.87
1	-32	-106	80	-32	-127.3	42.87
2	-32	-119	59	-32	-140.3	21.87
3	32	-119	59	32	-140.3	21.87
4	32	0	0	32	-21.3	-37.13
5	-32	0	0	-32	-21.3	-37.13

Multiple position commands can be applied to a point table. Below is the complete command list of the display list. Another position command influences the position of the part shown.

02:68 {02:290 {04:2A8}

02:68 positions the 04:2A8 display list in addition to the changes made by 02:290. The same process is used to move each of the points in the table. 02:68's position changes are shown in the short table below.

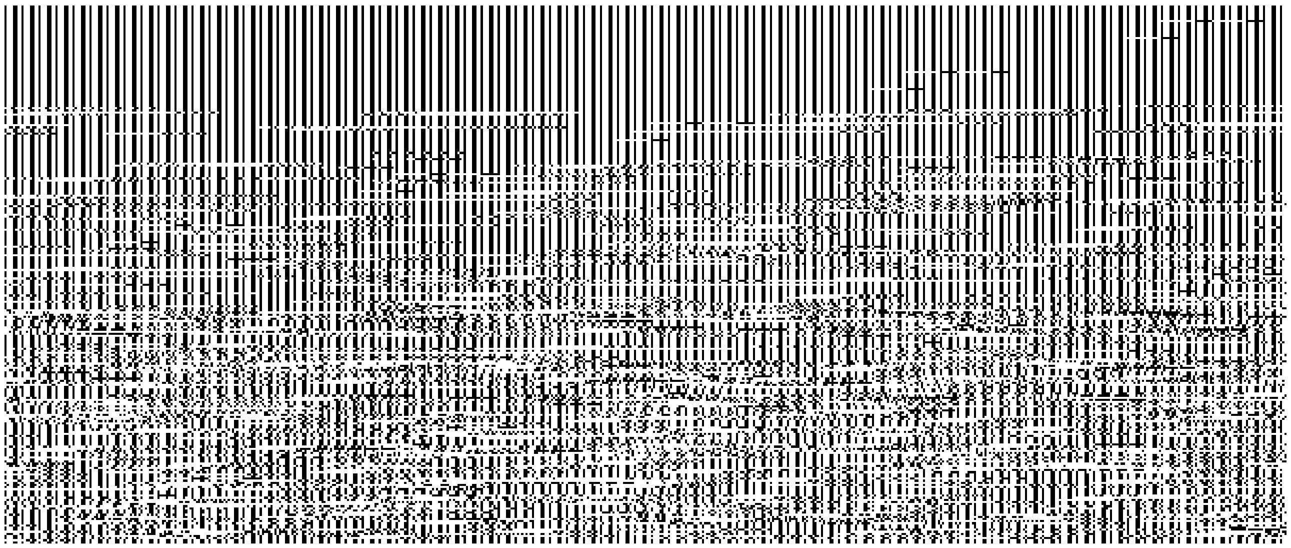
X modification	00000000	+0.
Y Modification	379F6230	+0.000019
Z Modification	C2FFE3EF	-127.95

The larger table below shows how the changes are compounded to create the final position. The original position values are given on the left, converted to their decimal equivalents. The middle columns denote the position changes made by the 02:290 position command, and the right-most columns illustrate the 02:68 position change.

#	X Org.	Y Org.	Z Org.	X First	Y First	Z First	X Final	Y Final	Z Final
0	32	−106	80	32	−127.3	42.87	32	−127.3	−85.08
1	−32	−106	80	−32	−127.3	42.87	−32	−127.3	−85.08
2	−32	−119	59	−32	−140.3	21.87	−32	−140.3	−106.08
3	32	−119	59	32	−140.3	21.87	32	−140.3	−106.08
4	32	0	0	32	−21.3	−37.13	32	−21.3	−165.08
5	−32	0	0	−32	−21.3	−37.13	−32	−21.3	−165.08

The right-most three columns are the final positions for each of the points in the point table. The total position change is equal to the position changes made by each of the parent position commands. Compounding position changes in this way moves the part to the final location in the rendered model.

	02:290	02:68	Total Change
X modification	+ 0.	+ 0.	+ 0.
Y Modification	−21.30	+ 0.000019	+ 21.300019
Z Modification	−37.13	−127.95	−165.08



Complex Display Lists: Point Aliasing

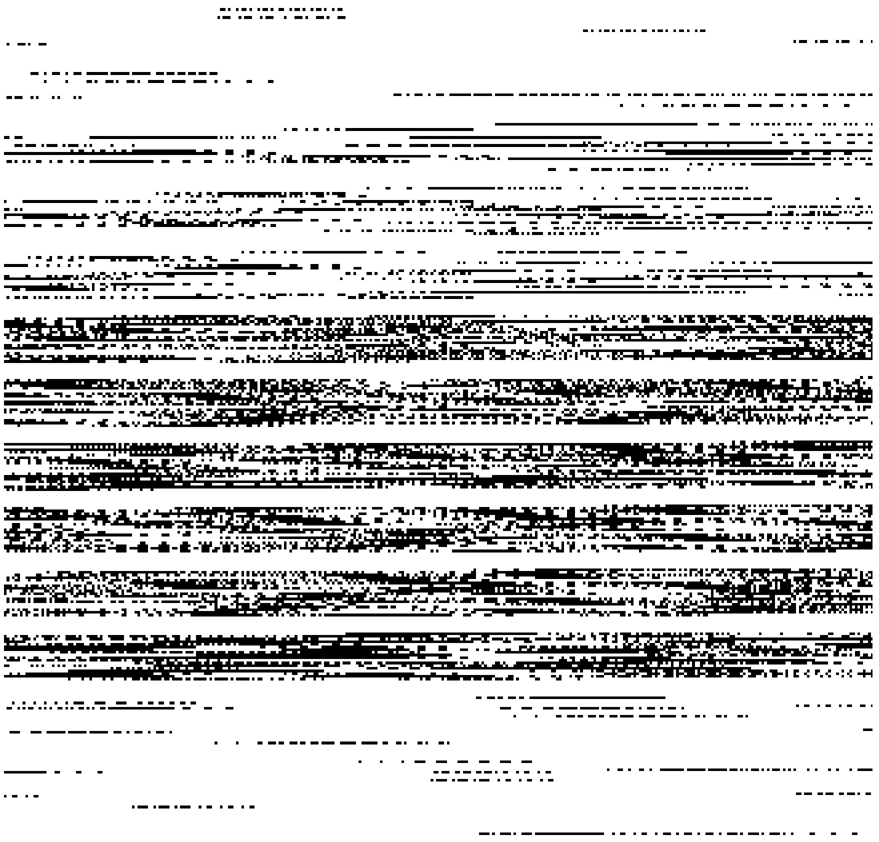
Type 18 display list commands contain more than just basic points used for rendering. There are two other groups of data contained in the block used for registering hit detection and merging points with different parts of the model. A complete 18 command's data is shown below.

Collision tables are a separate index of the unique points found in the rendering point list. The format differs slightly from the ordinary point tables, retaining x, y, and z position data but including an index value and information used later to merge coordinates. The format of the point structs will be discussed in the next section.

Contrast the two different kinds of point tables. On the left is a normal point table, and on the right is the collision table assigned to the same display list. Notice the fourth column in the collision point table, the index value, matches the point numbers on the left.

#	Rendering (Normal) Point Table							Collision Point Table						
0	FF9B	001E	FFB2	0000	000C	000A	303030FF	FF9B	001E	FFB2	0000	00000000	FFFF	0000
1	FF9B	FFC8	FFB8	0000	0037	000B	303030FF	FF9B	FFC8	FFB8	0001	00000000	FFFF	0000
2	FF9B	004B	00A2	0000	063E	002E	303030FF	FF9B	004B	00A2	0002	00000000	FFFF	0000
3	FF9B	FFCE	00AB	0000	067C	0030	303030FF	FF9B	FFCE	00AB	0003	00000000	FFFF	0000
4	FFBF	0026	0094	0000	05F8	0103	D4D4D4FF	FFBF	0026	0094	0004	00000000	FFFF	0000
5	FFF7	0030	FFFC	0000	0236	0239	5E5E5EFF	FFF7	0030	FFFC	0005	05000190	000D	0000
6	FFFC	FFDC	FFCC	0000	00FB	0256	5E5E5EFF	FFFC	FFDC	FFCC	0006	05000190	0011	0000
7	FFBD	FFEB	00AF	0000	06AA	00FB	E2E2E2FF	FFBD	FFEB	00AF	0007	00000000	FFFF	0000
8	0002	000C	FFBF	0000	00A6	0272	5E5E5EFF	0002	000C	FFBF	0008	05000190	000F	0000
9	0003	FFE1	FFEF	0000	01E4	0281	5E5E5EFF	0003	FFE1	FFEF	0009	05000190	0010	0000
A	0002	FFE7	0015	0000	02DF	0284	5E5E5EFF	0002	FFE7	0015	000A	05000190	000E	0000
B	FFFB	0020	FFE1	0000	0187	0252	5E5E5EFF	FFFB	0020	FFE1	000B	05000190	000C	0000

The two tables shown above looked very similar because each and every point in the rendering display list is unique. Often, though, this isn't the case. Only 16 points can be utilized at a time from a rendering point table, so often a point will need to be repeated later in the model. In addition, sometimes the same point will be used several times but utilize different mipmapping coordinates or coloration. As was previously stated, collision point tables only list *unique* coordinates, so it is not uncommon to see a collision table with fewer entries than a render table.


[illegible]

Notice there is not a 1-1 correspondence between the two tables. Instead, you have to resort to the index numbers in each table to see the relationship. Again, the rendered points are shown on the left, and the corresponding collision points to the right. Each of the index values is highlighted in blue.

#	Rendering (Normal) Point Table							Corresponding Collision Point Table						
0	000B	0009	FFDA	0000	02B1	00DD	BCBCBCFF	000B	0009	FFDA	0000	050004F0	0011	0000
1	000A	0021	0005	0000	0188	003B	BCBCBCFF	000A	0021	0005	0001	050004F0	0010	0000
2	0060	0017	FFDB	0000	0287	032C	F0F0F0FF	0060	0017	FFDB	0002	00000000	FFFF	0000
3	0009	0017	0023	0000	00BD	FFCD	D4D4D4FF	0009	0017	0023	0003	050004F0	000F	0000
4	006B	0032	002E	0000	0047	0252	F0F0F0FF	006B	0032	002E	0004	00000000	FFFF	0000
5	0060	0017	FFDB	0000	00A1	0231	F0F0F0FF							
6	0077	FFE7	FFCB	0000	0325	03A9	F0F0F0FF	0077	FFE7	FFCB	0006	00000000	FFFF	0000
7	000B	0009	FFDA	0000	015D	FFE9	BCBCBCFF							
8	000E	FFE5	FFDF	0000	0336	0094	D4D4D4FF	000E	FFE5	FFDF	0008	050004F0	000D	0000
9	000E	FFDF	0020	0000	02A3	038B	D4D4D4FF	000E	FFDF	0020	0009	050004F0	000E	0000
A	0082	FFE3	0033	0000	03D1	0028	F0F0F0FF	0082	FFE3	0033	000A	00000000	FFFF	0000
B	0009	0017	0023	0000	0026	0340	D4D4D4FF							
C	006B	0032	002E	0000	000D	003D	F0F0F0FF							
D	000E	FFE3	FFFE	0000	026D	0018	D4D4D4FF	000E	FFE3	FFFE	000D	050004F0	000C	0000
E	000E	FFE5	FFDF	0000	0143	002B	D4D4D4FF							
F	0077	FFE7	FFCB	0000	FFFF	028E	F0F0F0FF							
10	0082	FFE3	0033	0000	03DA	028F	F0F0F0FF							
11	000E	FFDF	0020	0000	03AF	0002	D4D4D4FF							
12	000E	FFE3	FFFE	0000	026D	0018	D4D4D4FF							
13	0077	FFE7	FFCB	0000	FFFF	028E	F0F0F0FF							
14	0077	FFE7	FFCB	0000	FFE9	021E	F0F0F0FF							
15	0060	0017	FFDB	0000	00A5	0348	F0F0F0FF							
16	0082	FFE3	0033	0000	03B1	023E	F0F0F0FF							
17	006B	0032	002E	0000	03B8	0416	F0F0F0FF							

Only the first instance of a point will be listed in the table. Notice in the table above point five, which doesn't have a collision table entry, is the same as point two. Normally, determining which collision entries pertain to rendering points would require string comparisons. Point usage tables circumvent this problem. The point usage table is a simple list of short integer values that indicate if other points in the table share the same location. The usage table for the above struct is given below.

A point usage value is usually FFFF, meaning the point is not shared by another in the table. If a value is given, though, it indicates the next entry ID that will use the exact same point. For instance, if entry 0's value is 0007, entry 7 will use the same collision point. This is noted in the table below.

#	Usage Table Entry		Corresponding Collision Point Table						
0	0007	Entry 7 is identical to entry 0	000B	0009	FFDA	0000	050004F0	0011	0000
1	FFFF	No matching entries	000A	0021	0005	0001	050004F0	0010	0000
2	0005	Entry 5 is identical to entry 2	0060	0017	FFDB	0002	00000000	FFFF	0000
3	000B	Entry B is identical to entry 3	0009	0017	0023	0003	050004F0	000F	0000
4	000C	Entry C is identical to entry 4	006B	0032	002E	0004	00000000	FFFF	0000
5	0015	Entry 15 is identical to entry 5	0060	0017	FFDB	0002	00000000	FFFF	0000
6	000F	Entry F is identical to entry 6	0077	FFE7	FFCB	0006	00000000	FFFF	0000
7	FFFF	No matching entries	000B	0009	FFDA	0000	050004F0	0011	0000
8	000E	Entry E is identical to entry 8	000E	FFE5	FFDF	0008	050004F0	000D	0000
9	0011	Entry 11 is identical to entry 9	000E	FFDF	0020	0009	050004F0	000E	0000
A	0010	Entry 10 is identical to entry A	0082	FFE3	0033	000A	00000000	FFFF	0000
B	FFFF	No matching entries	0009	0017	0023	0003	050004F0	000F	0000
C	0017	Entry 17 is identical to entry C	006B	0032	002E	0004	00000000	FFFF	0000
D	0012	Entry 12 is identical to entry D	000E	FFE3	FFFE	000D	050004F0	000C	0000
E	FFFF	No matching entries	000E	FFE5	FFDF	0008	050004F0	000D	0000
F	0013	Entry 13 is identical to entry F	0077	FFE7	FFCB	0006	00000000	FFFF	0000
10	0016	Entry 16 is identical to entry 10	0082	FFE3	0033	000A	00000000	FFFF	0000

11	FFFF	No matching entries	000E	FFDF	0020	0009	050004F0	000E	0000
12	FFFF	No matching entries	000E	FFE3	FFFE	000D	050004F0	000C	0000
13	0014	Entry 14 is identical to entry 13	0077	FFE7	FFCB	0006	00000000	FFFF	0000
14	FFFF	No matching entries	0077	FFE7	FFCB	0006	00000000	FFFF	0000
15	FFFF	No matching entries	0060	0017	FFDB	0002	00000000	FFFF	0000
16	FFFF	No matching entries	0082	FFE3	0033	000A	00000000	FFFF	0000
17	FFFF	No matching entries	006B	0032	002E	0004	00000000	FFFF	0000

When a point is adopted, it is as if that information is copied from the current location to the one given. Data copied in this way is highlighted in yellow above. This makes it possible to sequentially change multiple entries.

Entry 6 is copied four times above. Entry 6 is copied to entry F, the new entry F is copied to entry 13, and this new entry 13 is copied to entry 14. So long as the list is always processed from beginning to end, the table integrity will remain intact.

A single entry's collision entry can be recovered by examining the table. If a matching ID isn't found in the collision table, check for the value in the usage table. Then, check that the new entry isn't also aliased. Here is an example of the method, recovering the collision entry corresponding to entry 0x13.

Obtaining matching data from the collision table may not seem useful at the moment. However, it is essential to merging points between different pieces in models correctly.

Complex Display Lists: merging points

Point merging involves borrowing points from a different display list. Some models, most notably guards, are designed to be animated during play. To mask the gaps between each section of their body when moving point merging is used, connecting points in one model part to another.

This is a complicated process, involving four steps. Firstly, merging points should be done when translating positions. The reason for this is because the point taken from one part of a model may not be positioned the same as another part of the model. Just placing the point at its final position saves effort later when its location needs to be known.

The first step is determining which point is being replaced, and what point it is being replaced with. To understand how this is done, it is necessary to revisit the collision point table.

There are two values in the collision table used to look up and merge points. The *offset to merge table*, when set, indicates the display list that contains the point being taken. The *merge point number* states which point it is in the table. If the merge table pointer is NULL and the merge point number is -1, then no merging occurs. The point is as given.

When an offset appears in the *merge table pointer*, then the point at the specified index is connected physically to another part of the object. The offset will specify a display list command in the *Object Table.* Jump to the offset in the file and retrieve the command.

Offset	Type	Data Offset	Parent Offset	Next Entry	Previous Entry	Child Offset
0x4F0	00180000	0500356C	050004D8	00000000	00000000	00000000

The 18 command shown at the offset is the display list that contains the point being copied. The next step requires getting either the *point table offset* or the *collision point table offset* in the display list at offset 0x356C. It is easier to retrieve positions from the point table than parsing the collision points. Here is the display list data.

Offset	Mapping Offsets		Point Table	Points / Collision		Col. Table	Usage Table	
0x356C	050066F8	00000000	05003140	0026	0018	050033A0	05003520	0003 0000

The idea is to look up a particular point from this table, then copy the data over the original position given in the example above in red. The point number being copied is the *merge point number* highlighted above in purple. In this case, you want the point with ID 0x10. Point 0x10 will be copied from the point table at 0x3140. Only the x, y, and z values are required; copying the s/t values or RGBA can actually cause undesirable effects.

Offset	Point ID	X Position	Y Position	Z Position
0x3240	0x10	000E	FFDF	0020

Merging Points pt.2: *point translation*

However, points usually can not be copied as is. In most cases, different parts are positioned separately using the 02 position commands, as mentioned in the previous section. Usually every point in an object model is translated using the object's own position information as outlined in the *point translation* section above. However, the goal of merging points is to borrow a single point from another part of the model, and this part could be – and probably is – positioned differently. To correctly import a point, then, involves also determining its final location.

To properly import points, first the effects of any position commands have to be accounted for. To do this requires taking one more look at the object table command from before.

Offset	Type	Data Offset	Parent Offset	Next Entry	Previous Entry	Child Offset
0x4F0	00180000	0500356C	050004D8	00000000	00000000	00000000

This time the parent offset is necessary. By gathering a list of all the parent commands, any position commands that influence the display list can be noted. This was outlined in the last section on *parsing the object table.* A breakdown of these is shown below.

01:B8 {02:D0 {02:3B8 {02:448 {02:460 {0A:4C0 {08:4D8 {18:4F0}}}}}}}

There are four different position commands at work: 02:D0, 02:3B8, 02:448, and 02:460. Point translation is done normally on the point, as outlined in the *point translation section*. For convenience sake, the actual data is listed here

	02:D0	02:3B8	02:448	02:460	Total Change
X modification	+ 0.	+ 1.23	+ 211.71	+ 218.11	+ 431.05
Y Modification	+ 0.	+ 62.04	+ 272.09	+ 66.79	+ 400.92
Z Modification	+ 0.	+ 0.	+ 0.	+ 8.44	+ 8.44

	X Position	Y Position	Z Position
Original Hex	000E	FFDF	0020
Original Decimal	14	-33	32
New Positions	445.05	367.92	40.44

These new positions are copied over the original X, Y, and Z values from the point in the original example. Translation will become clearer in the final section, **Example of Object Output**, when an entire point table is translated and an object displayed at its final position. For now, lets focus on the last necessary part of point merging, *replacing point data.*

Merging Points pt. 3: point replacement

The final step, after translating the point, is to copy the point into the normal point table so the part can be displayed properly. As stated before, merging points is best done when the point table has been or is already being translated, and so this section assumes that every point has already been translated to its final position, ready for rendering. For this reason, all the position data shown below will be decimal values.

Now that the point has been translated, it is time to copy the point from the collision point table into the final point table. The point at the given index number and any other points that share the same location will be replaced with the new data. This has already been touched upon in the section on *point aliasing*, but now it will be practically applied.

The first step is to refer to the *point usage table* to determine what points will be replaced. Match the ID value for the collision point to the same entry in the point usage table. Below is a table illustrating this; note the points given in the table have already been translated.

#	Usage Table Entry		Corresponding Collision Point Table						
0	0007	Entry 7 is identical to entry 0	692.85	410.18	-22.	0000	050004F0	0011	0000
1	FFFF	No matching entries	445.05	367.92	40.44	0001	050004F0	0010	0000
...	Points 3-16								
17	FFFF	No matching entries	788.85	451.18	62.	0004	00000000	FFFF	0000

Point #1 is highlighted in yellow above. The table shows no other points share the same position, so only point 0001 will be replaced in the rendering point table. If other entries shared the same position, those would be replaced as well.

Now, to replace the matching entry in the point table. Since other entries share the position, only the ID given is changed, point ID #1. Below, highlighted in yellow and already translated to their new positioned, are the original rendering point and the matching collision point.

#	***Rendering Point Table, Translated***							***Collision Point Table, Translated***					
0	692.85	410.18	-22.	0000	02B1	00DD	BCBCBCFF	692.85	410.18	-22.	0000	050004F0	0011
1	691.85	434.18	21.	0000	0188	003B	BCBCBCFF	445.05	367.92	40.44	0001	050004F0	0010
...	Points 2-16												
17	788.85	451.18	62.	0000	03B8	0416	F0F0F0FF						

Copy and replace the original point table value with the new, converted point...

#	***New Rendering Point Table, Translated***						
1	445.05	367.92	40.44	0000	0188	003B	BCBCBCFF

Example of Object Output: *CdjbondZ Right Hand*

This isn't so much an example as a complete conversion of the right hand from Bond's dinner jacket model. The point positions are translated from their current positions to their final ones, all shared points merged, and the final model rendered. This example focuses on just one display list command, found at offset 0x4A8.

Offset	Type	Data Offset	Parent Offset	Next Entry	Previous Entry	Child Offset
0x100	00180000	050030F0	05000490	00000000	00000000	00000000

First, before anything else can be done, all the position commands affecting the part have to be determined. This is as simple as finding all the parent commands affecting the display list command. Retrieve the parent offset from the display list, then that command's parent and so on until the first command with no parent is found. This was described in the section on *parsing the object table*. Listed below are all the commands that affect the display list.

01:B8 {02:D0 {02:3B8 {02:448 {02:460 {02:478 {0A:490 {18:4A8}}}}}}}

As mentioned before, the value before the colon is the command type, and the value after the colon is the offset to the command. Five of the commands are 02 position types. Read each of these command's data pointers, then copy the position data found at that offset. A table of the values, converted to their decimal equivalents, is listed below.

	02:D0	02:3B8	02:448	02:460	02:478	Total Change
X modification	+ 0.	+ 1.23	+ 211.71	+ 218.11	+ 250.8	+ 681.85
Y Modification	+ 0.	+ 62.04	+ 272.09	+ 66.79	+ 0.26	+ 401.18
Z Modification	+ 0.	+ 0.	+ 0.	+ 8.44	+ 7.56	+ 16.0

The total change done to each point in the point table is equal to the sum of each of the position commands affecting it. The total change is given in the blue column to the very right.

The next step involves looking at the 18 command's data. Jump to the offset given in the command, 0x30F0. It contains the offsets to the point tables, usage table, and rendering commands. Right now, you need the *point table offset*. There are 24 (0x18) points in the table total.

Offset	Mapping Offsets		Point Table	Points / Collision		Col. Table	Usage Table	
0x356C	05006650	00000000	05002EA0	0018	000A	05003020	050030C0	0003 0000

Now, every point in the rendering point table is moved to the final position using the **total change** value. Simply add the change in x value to each point's x value, the change in y to the y values, and change in z to z values. This sets each point to their final positions. Notice in this table, only the x, y, & z values are shown, and each is converted to its decimal equivalent.

#	Org. X	Org. Y	Org. Z	New X	New Y	New Z
0	11	9	-38	692.85	410.85	-22
1	10	33	5	691.85	434.18	21
2	96	23	-37	777.85	424.18	-21
3	9	23	35	690.85	424.18	51
4	107	50	46	788.85	451.18	62
5	96	23	-37	777.85	424.18	-21
6	119	-25	-53	800.85	376.18	-37
7	11	9	-38	692.85	410.85	-22
8	14	-27	-33	695.85	374.18	-17
9	14	-33	32	695.85	368.18	48
A	130	-29	51	811.85	372.18	67
B	9	23	35	690.85	424.18	51
C	107	50	46	788.85	451.18	62
D	14	-29	-2	695.85	372.18	14
E	14	-27	-33	695.85	374.18	-17
F	119	-25	-53	800.85	376.18	-37
10	130	-29	51	811.85	372.18	67
11	14	-33	32	695.85	368.18	48
12	14	-29	-2	695.85	372.18	14
13	119	-25	-53	800.85	376.18	-37
14	119	-25	-53	800.85	376.18	-37
15	96	23	-37	777.85	424.18	-21
16	130	-29	51	811.85	372.18	67
17	107	50	46	788.85	451.18	62

The columns on the right show the final, transcribed positions. When the model is rendered at these locations, it will appear at the correct position relative to the rest of the body.

Now that all the rendering points are transcribed, points can be merged. To do this requires a look at the collision point table. There are only 10 point entries in this table. Any of those with a NULL merge offset can be ignored. Only those highlighted in yellow below are going to be used; the rest are not merged positions. Each one will be done individually.

X Position	Y Position	Z Position	Index	Merge Offset	Merge #	
000B	0009	FFDA	0000	050004F0	0011	0000
000A	0021	0005	0001	050004F0	0010	0000
0060	0017	FFDB	0002	00000000	FFFF	0000
0009	0017	0023	0003	050004F0	000F	0000
006B	0032	002E	0004	00000000	FFFF	0000
0077	FFE7	FFCB	0006	00000000	FFFF	0000
000E	FFE5	FFDF	0008	050004F0	000D	0000
000E	FFDF	0020	0009	050004F0	000E	0000
0082	FFE3	0033	000A	00000000	FFFF	0000
000E	FFE3	FFFE	000D	050004F0	000C	0000

Notice all of the selected merged points have the same merge offset. This is rather handy, since they'll all draw from the same point table. Right now lets take the first entry with a merge offset, the one with index 0000. You need point #11 from the table in 0x4F0. First, we'll extract the point from the proper display list entry. Jump to the command at offset 0x4F0. This is the same block the original *point merging* example referred to.

Offset	Type	Data Offset	Parent Offset	Next Entry	Previous Entry	Child Offset
0x4F0	00180000	0500356C	050004D8	00000000	00000000	00000000

Highlighted in blue is the offset to the display list data. In yellow is the parent offset, in order to find all the position entries that affect the point. This will be done first. You could translate every point table's entries before attempting to merge points, but in this example it is assumed only the current block has been translated. As described before, retrieve a list of all the parent commands, then filter out the ones that set part positions.

01:B8 {02:D0 {02:3B8 {02:448 {02:460 {0A:4C0 {08:4D8 {18:4F0}}}}}}}

There are four different position commands at work: 02:D0, 02:3B8, 02:448, and 02:460. Point translation is done normally on the point, as outlined in the *point translation section*. For convenience sake, the actual data is listed here

	02:D0	02:3B8	02:448	02:460	Total Change
X modification	+ 0.	+ 1.23	+ 211.71	+ 218.11	+ 431.05
Y Modification	+ 0.	+ 62.04	+ 272.09	+ 66.79	+ 400.92
Z Modification	+ 0.	+ 0.	+ 0.	+ 8.44	+ 8.44

Once the point in question has been extracted, the values in the *total change* column are added to the point, converting it to its final position. To extract the point, jump to the display list data offset at 0x356C – the one highlighted in blue in the table above.

Offset	Mapping Offsets		Point Table	Points / Collision		Col. Table	Usage Table	
0x356C	05006650	00000000	05002EA0	0018	000A	05003020	050030C0	0003 0000

You need to get the 11th point from the point table. Every point in the table is 16 (0x10) bytes long, so the address of the point you need is at 0x110 + 0x2EA0, or 0x2FB0. Retrieve the x, y, and z values of this point...

000E FFDF 0020

–and add the total position modifier from the *total change* column for this part.

	X Position	Y Position	Z Position
Original Hex	000E	FFDF	0020
Original Decimal	14	-33	32
New Positions	445.05	367.92	40.44

The new position will replace the x, y, and z of any points set to the original location. In order to do replacement, we need to look at the point usage table for the original point. Any entries that share the same point as index 0 will also be moved. The point usage table is at 0x30C0. Each entry is two bytes, so each entry can be looked up by its ID.

2*ID + 0x30C0 = offset to matching entry

Both points 0 and 7 in the original point table will be replaced with the new values. Now, a quick look at the point table so far. Each entries coordinates have been translated to the new position. Entries 0 and 7, highlighted in purple, have both been replaced with their new, merged positions.

#	New X	New Y	New Z	-	S img	T img	RGBA
0	445.05	367.92	40.44	0000	02B1	00DD	BCBCBCFF
1	691.85	434.18	21	0000	0188	003B	BCBCBCFF
2	777.85	424.18	-21	0000	0287	032C	F0F0F0FF
3	690.85	424.18	51	0000	00BD	FFCD	D4D4D4FF
4	788.85	451.18	62	0000	0047	0252	F0F0F0FF
5	777.85	424.18	-21	0000	00A1	0231	F0F0F0FF
6	800.85	376.18	-37	0000	0325	03A9	F0F0F0FF
7	445.05	367.92	40.44	0000	015D	FFE9	BCBCBCFF
8	695.85	374.18	-17	0000	0336	0094	D4D4D4FF
9	695.85	368.18	48	0000	02A3	038B	D4D4D4FF
A	811.85	372.18	67	0000	03D1	0028	F0F0F0FF
B	690.85	424.18	51	0000	0026	0340	D4D4D4FF
C	788.85	451.18	62	0000	000D	003D	F0F0F0FF
D	695.85	372.18	14	0000	026D	0018	D4D4D4FF
E	695.85	374.18	-17	0000	0143	002B	D4D4D4FF
F	800.85	376.18	-37	0000	FFFF	028E	F0F0F0FF
10	811.85	372.18	67	0000	03DA	028F	F0F0F0FF
11	695.85	368.18	48	0000	03AF	0002	D4D4D4FF
12	695.85	372.18	14	0000	026D	0018	D4D4D4FF
13	800.85	376.18	-37	0000	FFFF	028E	F0F0F0FF
14	800.85	376.18	-37	0000	FFE9	021E	F0F0F0FF
15	777.85	424.18	-21	0000	00A5	0348	F0F0F0FF
16	811.85	372.18	67	0000	03B1	023E	F0F0F0FF
17	788.85	451.18	62	0000	03B8	0416	F0F0F0FF

The next point to do is index 0001, calling for point #10 from the table in 0x4F0. This is the same table as before, so it isn't necessary to recompute the position modifiers and get the offsets – it has already been done before. Read the x, y, and z values from the 10th point in 0x2EA0: 0x100 + 0x2EA0, or 0x2FA0. After retrieving the point, apply the position modifier.

	X Position	Y Position	Z Position
Original Hex	0082	FFE3	0033
Original Decimal	130	-29	51
Modifier	+431.05	+400.92	+8.44
New Positions	561.05	371.92	59.44

Now, to check the point usage table. Again, the table is found at 0x30C0. This time, index 0001 is going to be checked. You can determine the address by multiplying the index by 2 and adding it to the table offset.

```
0x30C2     FFFF
```

No other points share this position, so only point #1 will be replaced. The newly changed value is highlighted in purple in the table below, and those changed previously in blue. Again, the point list as it stands now. Only four more points to go...

#	New X	New Y	New Z	-	S img	T img	RGBA
0	445.05	367.92	40.44	0000	02B1	00DD	BCBCBCFF
1	561.05	371.92	59.44	0000	0188	003B	BCBCBCFF
2	777.85	424.18	-21	0000	0287	032C	F0F0F0FF
3	690.85	424.18	51	0000	00BD	FFCD	D4D4D4FF
4	788.85	451.18	62	0000	0047	0252	F0F0F0FF
5	777.85	424.18	-21	0000	00A1	0231	F0F0F0FF
6	800.85	376.18	-37	0000	0325	03A9	F0F0F0FF
7	445.05	367.92	40.44	0000	015D	FFE9	BCBCBCFF
8	695.85	374.18	-17	0000	0336	0094	D4D4D4FF
9	695.85	368.18	48	0000	02A3	038B	D4D4D4FF
A	811.85	372.18	67	0000	03D1	0028	F0F0F0FF
B	690.85	424.18	51	0000	0026	0340	D4D4D4FF
C	788.85	451.18	62	0000	000D	003D	F0F0F0FF
D	695.85	372.18	14	0000	026D	0018	D4D4D4FF
E	695.85	374.18	-17	0000	0143	002B	D4D4D4FF
F	800.85	376.18	-37	0000	FFFF	028E	F0F0F0FF
10	811.85	372.18	67	0000	03DA	028F	F0F0F0FF
11	695.85	368.18	48	0000	03AF	0002	D4D4D4FF
12	695.85	372.18	14	0000	026D	0018	D4D4D4FF
13	800.85	376.18	-37	0000	FFFF	028E	F0F0F0FF
14	800.85	376.18	-37	0000	FFE9	021E	F0F0F0FF
15	777.85	424.18	-21	0000	00A5	0348	F0F0F0FF
16	811.85	372.18	67	0000	03B1	023E	F0F0F0FF
17	788.85	451.18	62	0000	03B8	0416	F0F0F0FF

The next entry being merged is index 0003, requesting point 0xF from display list command 0x4F0. Do this point just like the last two, computing position and retrieving the point from the point table. Since the position is the same as the last two, compute the offset to the point. 0xF0 + 0x2EA0 = 0x2F90. The point data is shown below, and the position modification is applied.

	X Position	Y Position	Z Position
Original Hex	0077	FFE7	FFCB
Original Decimal	119	-25	-53
Modifier	+431.05	+400.92	+8.44
New Positions	550.05	375.92	-44.56

Now, to check the point usage table again. You want entry 3, which is found at 2*3 + 0x30C0 = 0x30C6.

Now, replace both entries 3 and B in the point table with the new entries. The current list is below, and again, the new entries are in purple and other replaced entries in blue.

#	New X	New Y	New Z	-	S img	T img	RGBA
0	445.05	367.92	40.44	0000	02B1	00DD	BCBCBCFF
1	561.05	371.92	59.44	0000	0188	003B	BCBCBCFF
2	777.85	424.18	-21	0000	0287	032C	F0F0F0FF
3	550.05	375.92	-44.56	0000	00BD	FFCD	D4D4D4FF
4	788.85	451.18	62	0000	0047	0252	F0F0F0FF
5	777.85	424.18	-21	0000	00A1	0231	F0F0F0FF
6	800.85	376.18	-37	0000	0325	03A9	F0F0F0FF
7	445.05	367.92	40.44	0000	015D	FFE9	BCBCBCFF
8	695.85	374.18	-17	0000	0336	0094	D4D4D4FF
9	695.85	368.18	48	0000	02A3	038B	D4D4D4FF
A	811.85	372.18	67	0000	03D1	0028	F0F0F0FF
B	550.05	375.92	-44.56	0000	0026	0340	D4D4D4FF
C	788.85	451.18	62	0000	000D	003D	F0F0F0FF
D	695.85	372.18	14	0000	026D	0018	D4D4D4FF
E	695.85	374.18	-17	0000	0143	002B	D4D4D4FF
F	800.85	376.18	-37	0000	FFFF	028E	F0F0F0FF
10	811.85	372.18	67	0000	03DA	028F	F0F0F0FF
11	695.85	368.18	48	0000	03AF	0002	D4D4D4FF
12	695.85	372.18	14	0000	026D	0018	D4D4D4FF
13	800.85	376.18	-37	0000	FFFF	028E	F0F0F0FF
14	800.85	376.18	-37	0000	FFE9	021E	F0F0F0FF
15	777.85	424.18	-21	0000	00A5	0348	F0F0F0FF
16	811.85	372.18	67	0000	03B1	023E	F0F0F0FF
17	788.85	451.18	62	0000	03B8	0416	F0F0F0FF

The next point being merged is index 0008, retrieving point 0xD from the command 0x4F0. Again, since the same table is being used, the position and offsets are the same as before. Calculate the offset to the data, copy it, then apply the position change. The point is found at 0xD0 + 0x2EA0 = 0x2F70.

	X Position	Y Position	Z Position
Original Hex	000E	FFE3	FFFE
Original Decimal	14	-29	-2
Modifier	+431.05	+400.92	+8.44
New Positions	445.05	371.92	6.44

Now, check the point usage table to see if any other points in the table share the same location.

Now simply replace both points 8 and E with the new position computed above. The new table is listed below with the new points highlighted in purple.

#	New X	New Y	New Z	-	S img	T img	RGBA
0	445.05	367.92	40.44	0000	02B1	00DD	BCBCBCFF
1	561.05	371.92	59.44	0000	0188	003B	BCBCBCFF
2	777.85	424.18	-21	0000	0287	032C	F0F0F0FF
3	550.05	375.92	-44.56	0000	00BD	FFCD	D4D4D4FF
4	788.85	451.18	62	0000	0047	0252	F0F0F0FF
5	777.85	424.18	-21	0000	00A1	0231	F0F0F0FF
6	800.85	376.18	-37	0000	0325	03A9	F0F0F0FF
7	445.05	367.92	40.44	0000	015D	FFE9	BCBCBCFF
8	445.85	371.92	6.44	0000	0336	0094	D4D4D4FF
9	695.85	368.18	48	0000	02A3	038B	D4D4D4FF
A	811.85	372.18	67	0000	03D1	0028	F0F0F0FF
B	550.05	375.92	-44.56	0000	0026	0340	D4D4D4FF
C	788.85	451.18	62	0000	000D	003D	F0F0F0FF
D	695.85	372.18	14	0000	026D	0018	D4D4D4FF
E	445.85	371.92	6.44	0000	0143	002B	D4D4D4FF
F	800.85	376.18	-37	0000	FFFF	028E	F0F0F0FF
10	811.85	372.18	67	0000	03DA	028F	F0F0F0FF
11	695.85	368.18	48	0000	03AF	0002	D4D4D4FF
12	695.85	372.18	14	0000	026D	0018	D4D4D4FF
13	800.85	376.18	-37	0000	FFFF	028E	F0F0F0FF
14	800.85	376.18	-37	0000	FFE9	021E	F0F0F0FF
15	777.85	424.18	-21	0000	00A5	0348	F0F0F0FF
16	811.85	372.18	67	0000	03B1	023E	F0F0F0FF
17	788.85	451.18	62	0000	03B8	0416	F0F0F0FF

Only two points remain. The first is index 9, drawing point 0xE from the 0x4F0 command. Compute the offset to the point, copy it, and apply the position modifier. The point is located at 0xE0 + 0x2EA0, or 0x2F80. The data is shown in the table below.

	X Position	Y Position	Z Position
Original Hex	000E	FFE5	FFDF
Original Decimal	14	-27	-33
Modifier	+431.05	+400.92	+8.44
New Positions	445.05	373.92	-24.56

Now check entry 9 in the *point usage table*. The offset is 2∗9 + 0x30C0, or 0x30D2.

Before showing the updated table the final merged point will be handled. This uses index 000D and calls for point C from the 0x4F0 display list. Again, since this is the same binary as the rest of the points, all the same positions and offsets are in effect. Draw the point from the calculated offset: 0xC0 + 0x2EA0 = 0x2F60

	X Position	Y Position	Z Position
Original Hex	006B	0032	002E
Original Decimal	107	50	46
Modifier	+431.05	+400.92	+8.44
New Positions	538.05	450.92	54.44

Look up entry D in the point usage table. Replace all the points that share this new position.

Now, just replace the points in the rendering table with the new ones. Below is the final point table. You are now ready to render the object, and with the updated point data this part will render at exactly the correct position relative to the rest of the model.

In conclusion, point merging is slightly complicated but by no means difficult. You apply the same technique to every part of the model. Scan though the point usage table for a merge pointer. Use that pointer to retrieve a list of its parent commands to determine the position mod to apply to the point. Use its data offset to retrieve the correct merge point number, then copy the result to every identical location in the original part.

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#	New X	New Y	New Z	-	S img	T img	RGBA
0	445.05	367.92	40.44	0000	02B1	00DD	BCBCBCFF
1	561.05	371.92	59.44	0000	0188	003B	BCBCBCFF
2	777.85	424.18	-21	0000	0287	032C	F0F0F0FF
3	550.05	375.92	-44.56	0000	00BD	FFCD	D4D4D4FF
4	788.85	451.18	62	0000	0047	0252	F0F0F0FF
5	777.85	424.18	-21	0000	00A1	0231	F0F0F0FF
6	800.85	376.18	-37	0000	0325	03A9	F0F0F0FF
7	445.05	367.92	40.44	0000	015D	FFE9	BCBCBCFF
8	445.85	371.92	6.44	0000	0336	0094	D4D4D4FF
9	445.05	373.92	-24.56	0000	02A3	038B	D4D4D4FF
A	811.85	372.18	67	0000	03D1	0028	F0F0F0FF
B	550.05	375.92	-44.56	0000	0026	0340	D4D4D4FF
C	788.85	451.18	62	0000	000D	003D	F0F0F0FF
D	538.05	450.92	54.44	0000	026D	0018	D4D4D4FF
E	445.85	371.92	6.44	0000	0143	002B	D4D4D4FF
F	800.85	376.18	-37	0000	FFFF	028E	F0F0F0FF
10	811.85	372.18	67	0000	03DA	028F	F0F0F0FF
11	445.05	373.92	-24.56	0000	03AF	0002	D4D4D4FF
12	538.05	450.92	54.44	0000	026D	0018	D4D4D4FF
13	800.85	376.18	-37	0000	FFFF	028E	F0F0F0FF
14	800.85	376.18	-37	0000	FFE9	021E	F0F0F0FF
15	777.85	424.18	-21	0000	00A5	0348	F0F0F0FF
16	811.85	372.18	67	0000	03B1	023E	F0F0F0FF
17	788.85	451.18	62	0000	03B8	0416	F0F0F0FF