





Agenda

Power Systems

- What is a null-capable field?
- Working with null-capable fields in RPG
- Working with null-capable fields in embedded SQL
- Trigger programs



Null-capable fields

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- A null-capable field has
- Its value, 3.2, 'Jack Sprat' etc.
- An associated value that says whether it is null or not, called a "null indicator"
- If the null indicator is "on", then the value in the field is meaningless.
- For example, if a customer does not have any orders, the duedate for the orders is meaningless, so it may be useful to define the "duedate" field as null-capable, to avoid trying to use the date's value when it has no meaning.



Defining a field as null-capable in a file

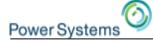
When you create a table with SQL, fields are null-capable by default

```
CREATE TABLE MYLIB/TESTNULL
(NUM_ORDERS DECIMAL (7, 0) NOT NULL WITH DEFAULT,
DUE_DATE DATE)
```

- The NUM_ORDERS field is defined with "NOT NULL WITH DEFAULT", so it is not null capable
- The DUE_DATE field does not have "NOT NULL", so it is null-capable
- In DDS, you use the ALWNULL keyword

A R REC

- A NUM_ORDERS 7P 0
- A DUE_DATE L DATFMT(*ISO) ALWNULL

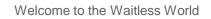




The "null-byte map"

The I/O buffer for a file has a separate section called the "nullbyte map" which has an indicator for each field in the file indicating whether it is null or not.

(If the field is not null-capable, the null-byte-map indicator for that field is always '0'.)





The "null-byte map"

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Imagine a file with three fields

- NAME: not null-capable
- DUEDATE: null-capable
- PRVBAL: null-capable

Here are the I/O buffer and null-byte map for a sample record

Buffer: Jack Sprat 0001-01-010041.75

Null-byte map: 010

Null-capable field "DUEDATE" has the null-value. Its value of 0001-01-01 is meaningless.



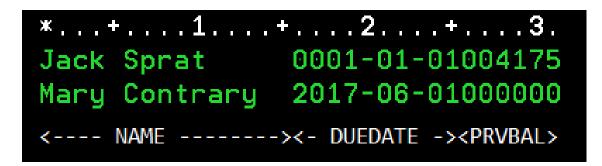
Displaying null-valued fields

STRSQL output

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+1+	2 +	+.
NAME	DUEDATE	PRVBAL
Jack Sprat	-	41.75
Mary Contrary	17/06/01	-

DSPPFM output shows the default value. Why?





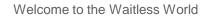
Displaying null-valued fields

The "field" part of a null-capable field always has a value, even if the null-indicator is on.

DSPPFM shows the values of the "field" part of a field. It does not have any way to show the null-indicators.

- For the record 1, DUEDATE is null. The field value is '0001-01-01'.
- For the record 2, PRVBAL is null. The field value is 0000.00.

*+1	+3.
Jack Sprat	0001-01-01004175
Mary Contrary	2017-06-01000000
< NAME	-><- DUEDATE -> <prvbal></prvbal>



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ALWNULL(*USRCTL) keyword

To work with null-capable fields in your RPG module, you need to compile with ALWNULL(*USRCTL)

Either

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- As a command parameter
- As an H-spec keyword

I recommend using the H-spec keyword, to ensure the module is always compiled correctly



The null-byte indicator in RPG

The associated null-indicator for null-capable fields is an internal variable maintained by the RPG compiler.

- Prior to 7.3, this was always the case.
- Starting in 7.3 this is the default (more on this later)

You refer to the null-indicator using the %NULLIND built-in function

```
dueDate = curDate + %days(30);
%nullind(dueDate) = *off; // set to "not null"
read custfile;
if %nullind(duedate); // check if null
```

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Reading a record with null-capable fields

When you read a record containing null-capable fields

- The buffer values get moved into the program fields
- The null-byte map values get moved into the associated nullindicators of the null-capable fields

```
Buffer: Jack Sprat
Null-byte map: 010
```

0001-01-010041.75

<pre>ctl-opt alwnull(*usrctl);</pre>		EVAL name NAME = 'Jack Sprat ' EVAL duedate DUEDATE = '0001-01-01'
<pre>dcl-f custfile; read custrec;</pre>	>	EVAL _QRNU_NULL_DUEDATE _QRNU_NULL_DUEDATE = '1' EVAL PRVBAL DUEDATE = 41.75 EVAL _QRNU_NULL_PRVBAL _QRNU_NULL_PRVBAL = '0'

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Writing a record with null-capable fields

When you write or update a record containing null-capable fields

- The program field values get moved into the buffer
- The associated null-indicators of the null-capable fields get moved into the null-byte map. The null-byte map for the nonnull-capable fields is set to '0'.

```
dueDate = curDate + %days(30);
%nullind(dueDate) = *off; // not null
update custrec;
```

```
Buffer: Jack Sprat 2016-06-150041.75
Null-byte map: 000
```



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If you forget to set off the null-indicator

After the update, DUEDATE is still null!

*...+...1...+...2...+...3.
Jack Sprat 0001-01-01004175



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How to define null-capable fields in RPG

When ALWNULL(*USRCTL) is in effect ...

- If a field in a file is null-capable, the following RPG fields are also null-capable
- Fields from externally-described files
- Subfields in externally-described data structures



How to define null-capable fields in RPG

```
ctl-opt alwnull(*usrctl);
dcl-f testnull;
dcl-ds extds extname('TESTNULL') qualified end-ds;
```

Null-capable fields are indicated in the cross reference with "ALWNULL":

Global Field References:

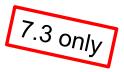
Field DUEDATE	Attributes D(10*ISO-) ALWNULL	(From the file declaration)
EXTDS	DS(31)	
DUEDATE	D(10*ISO-)	(Data structure subfield)
	ALWNULL	
NAME	A(15)	(Data structure subfield)
PRVBAL	S(6,2)	(Data structure subfield)
	ALWNULL	
NAME	A(15)	(From the file declaration)
PRVBAL	P(6,2)	(From the file declaration)
	ALWNULL	

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Define your own null-capable fields



You can define your own null-capable fields starting in 7.3

```
Use the NULLIND keyword
dcl-s qty int(10) nullind;
```

- Field qty is null-capable
- The null-indicator is maintained internally by the RPG compiler, similar to null-capable fields related to externallydescribed files or data structures



Define your own null-capable fields and null-indicators

You can use your own indicator as the null-indicator for a field

```
Use NULLIND(my_indicator):
```

```
dcl-s qty_is_null ind;
dcl-s qty int(10) nullind (qty_is_null);
```

You can refer to the null indicator using its name, or using %NULLIND. These mean the same thing:

if qty_is_null;

if %nullind(qty);



7.3 only

Define your own null-capable subfields

You can associate an indicator subfield to be the null-indicator for another subfield in the same data structure

```
dcl-ds myds qualified;
    qty int(10) nullind(qty_is_null);
    qty_is_null ind(10);
end-ds;
```

As always, you can refer to the null indicator using its name, or using %NULLIND. These mean the same thing:

```
if myds.qty_is_null;
```

```
if %nullind(myds.qty);
```



Define your own null-byte map for a data structure,

Use the NULLIND keyword to associate a data structure of null indicators with a data structure to represent whether the subfields are null.

The NULLIND data structure represents the null-byte map for the other data structure.

Use EXTNAME LIKEREC with *NULL to define the data structure of null indicators ...



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LIKEREC(rec:*NULL) and EXTNAME(file:*NULL)

*NULL defines a null-map data structure with indicator subfields instead of the actual types of the fields in the file.

The indicator subfields have the same names as the fields in the file.

```
dcl-ds cust_ds likerec(custrec) nullind(cust_null);
dcl-ds cust_null likerec(custrec : *null);
```

```
read custfile cust_ds;
if not cust_null.duedate; // duedate is not null
```



LIKEREC(rec:*NULL) and EXTNAME(file:*NULL)

If the main data structure has a specific extract type (*INPUT etc), define the NULLIND data structure the same way, adding *NULL.

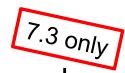
```
dcl-ds cust_ds likerec(rec : *output) nullind(cust_null);
dcl-ds cust_null likerec(rec : *output : *null);
```

Here, the two data structures represent the output record format.

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*NULL – easier to work with trigger parameters



In trigger programs, there is a null byte map for the before and after record.

Before: Locate the null-indicator by its field number

```
dcl-s nullmap1 char(100) based(pNullmap1);
```

```
pNullmap1 = %addr(trigger_buffer) + null_offset1;
if %subst(nullmap1 : 2 : 1) = '1';
```

```
Now, less error-prone:
    dcl-ds nullmap1 extname('CUSTFILE':*NULL)
        qualified based(pNullmap1) end-ds;
```

```
pNullmap1 = %addr(trigger_buffer) + before_null_offset;
if nullmap1.duedate;
```

Bonus: duedate is an indicator, so there is no need to compare it to '1' now.

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When does RPG handle the null-indicator?

ALWNULL(*USRCTL) stands for "user controlled"

• The "user" is the RPG programmer

RPG sets or uses the null-indicator automatically in a few places

- When a null-capable field is read from a file (the nullindicator is set off if the field is not null-capable in that particular file)
- When a null-capable field is written or updated to a file
- When a null-capable field is used as a key in a list of key fields or %KDS
- During the EVAL-CORR opcode



When does RPG not handle the null-indicator?

RPG does not handle the null-indicator

• When a value is assigned to the null-capable field, the nullindicator is not set on

dueDate = curDate + %days(30); %nullind(dueDate) = *off; // Must be explicitly set

• When a null-capable field is used in a calculation, the nullindicator is ignored

%nullind(dueDate) = *on; // DUEDATE is meaningless now
final_date = duedate + %days(30); // But RPG allows this



EVAL-CORR

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- EVAL-CORR assigns subfields with the same name and compatible data types
- It also assigns null-indicators
- If both the source and target subfields are null-capable, both the value and the null-indicator are assigned
- If the target is null-capable and the source is not nullcapable, the value is assigned and the target null-indicator is set off
- If the source is null-capable and the target is not nullcapable, the value is assigned and the source null-indicator is ignored



Welcome to the Waitless World



EVAL-CORR

<pre>dcl-ds ds1 qualified; a char(10); b char(10) nullind; c char(10); d char(10) nullind; end-ds;</pre>	<pre>%nullind(ds2.c) = *on; %nullind(ds1.d) = *on; eval-corr ds1 = ds2; // Equivalent to</pre>
<pre>end-ds; dcl-ds ds2 qualified; a char(10); b char(10); c char(10) nullind; d char(10) nullind; end-ds;</pre>	<pre>// Equivalent to ds1.a = ds2.a; ds1.b = ds2.b; %nullind(ds1.b) = '0'; ds1.c = ds2.c; ds1.d = ds2.d; %nullind(ds1.d) = %nullind(ds2.d);</pre>



EVAL-CORR

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From the EVAL-CORR summary in the listing

EVAL-CORR Summary 1 20 EVAL-CORR summary 1 20 A Assigned; exact match B Assigned; exact match Target subfield is null-capable; source subfield is not C Assigned; exact match Source subfield is null-capable; target subfield is not

D Assigned; exact match



Checking/setting the null-indicator in the debugger

If the null-indicator is an internal field which can only be accessed by %NULLIND

• The name of the null-indicator in the debugger is

_QRNU_NULL_<name>

If PRVBAL is null-capable, the null-indicator is called __QRNU_NULL_PRVBAL

If CUST.DUEDATE is null-capable, the null-indicator is called _QRNU_NULL_CUST.DUEDATE

If you used NULLIND to associate your own indicator with the field, the _QRNU_NULL_ debug field does not exist

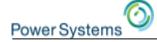
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Null-capable fields in embedded SQL

- A normal host variable is specified with :varname
- To specify the null-indicator for a host variable, you specify two names, the variable holding the value and the variable holding the null indicator
 - :fldname :nullindname

In the following example, a null-indicator is specified for fld1 and fld3, but not for fld2.



Null-capable fields in embedded SQL

SQL null-indicators are two-byte integers (5i, or sometimes people use 2b or 4b)

- 0 means "not null"
- -1 means "null"

RPG null indicators have the same data type as other RPG indicators (single-byte character)

- '0' means "not null"
- '1' means "null"

SQL doesn't understand the %NULLIND relationship for RPG, and RPG doesn't have any concept of numeric null indicators



SQL null indicators vs RPG null indicators

If your SQL null indicators only contain 0 and -1, you can convert between RPG and SQL null-indicators like this:

```
ind_sql = %int(ind_rpg) * -1;
OR
ind_sql = - %int(ind_rpg);
// '1' -> -1
// '0' -> 0
ind_rpg = %char(%abs(ind));
// -1 -> '1'
// 0 -> '0'
```

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Special values for null indicators in embedded SQL

There are several other negative values that have special meanings in certain contexts. For example

- A null-indicator value of -5 means "use the default value" for an INSERT operation
- A null-indicator of -2 means there was some error in the field's value for a SELECT operation
- See the "**References to host variables**" page in the knowledge center for more information about the special values for null indicators in embedded SQL

Note: These special values are only in effect if you compile with option *EXTIND (extended indicator support).



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Working with the null-byte maps in trigger programs

A trigger program parameter has four "buffer" sections

- The "before" buffer
- The "before" null-byte map
- The "after" buffer
- The "after" null-byte map

They are accessed using offsets in the first part of the parameter. From QSYSINC/QRPGLESRC TRGBUF:

D QDBORO	49	52I <mark>0</mark>	Old Record Offset
D QDBORL	53	56I <mark>0</mark>	Old Record Len
D QDBORNBM	57	60I <mark>0</mark>	Old Record Null Byte Map
D QDBRNBML	61	64I <mark>0</mark>	Old Record Null Byte Map Len
D QDBNRO	65	68I <mark>0</mark>	New Record Offset
D QDBNRL	69	72I 0	New Record Len
D QDBNRNBM	73	76I <mark>0</mark>	New Record Null Byte Map
D QDBRNBML00	77	80I <mark>0</mark>	New Record Null Byte Map Len



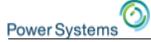


Null-byte maps in trigger programs prior to 7.3

```
/copy gsysinc/grpglesrc,trgbuf
dcl-pi *n;
               // The parameter to this program
 parm likeds(QDBTB); // QDBTB defined in QSYSINC TRGBUF
end-pi;
// Define based data structures for file
dcl-ds beforeBuf extname('TESTNULL' : *INPUT)
                 qualified based(pBeforeBuf) end-ds;
dcl-ds beforeNull qualified based(pBeforeNull);
  NAME ind;
  DUEDATE ind;
  PRVBAL ind;
end-ds;
dcl-ds afterBuf
                extname('TESTNULL' : *INPUT)
                 qualified based(pAfterBuf) end-ds;
dcl-ds afterNull
                 likeds(beforeNull) based(pAfterNull);
```

For the null-byte map (beforeNull and afterNull), define one indicator for each field in the file

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Null-byte maps in trigger programs prior to 7.3

```
// Set the basing pointers using the offsets in the parameter
pBeforeBuf = %addr(parm) + parm.QDBORO;
pBeforeNull = %addr(parm) + parm.QDBORNBM;
pAfterBuf = %addr(parm) + parm.QDBNRO;
pAfterNull = %addr(parm) + parm.QDBNRNBM;
```

// Do some checking
if afterNull.DUEDATE
and afterDs.PRVBAL <> *zero and not afterNull.PRVBAL;
 sndEscapeMsg ('PRVBAL must be zero if DUEDATE is null');
endif;



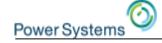
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The null-byte maps in trigger programs, 7.3

```
ctl-opt alwnull(*usrctl);
/copy qsysinc/qrpglesrc,trgbuf
```

```
dcl-pi *n; // The parameter to this program
    parm likeds(QDBTB); // QDBTB defined in QSYSINC TRGBUF
end-pi;
```

```
// Define based data structures for file TESTNULL
// - Link the null-byte map data structures to the
// "ordinary" buffer structures using NULLIND
dcl-ds beforeBuf extname('TESTNULL' : *INPUT)
                  qualified based(pBeforeBuf)
                  nullind(beforeNull) end-ds;
                                                        7.3 only
dcl-ds beforeNull extname('TESTNULL' : *INPUT : *NULL)
                  qualified based(pBeforeNull) end-ds;
                  extname('TESTNULL' : *INPUT)
dcl-ds afterBuf
                  qualified based(pAfterBuf)
                  nullind(afterNull) end-ds;
dcl-ds afterNull
                  extname('TESTNULL' : *INPUT : *NULL)
                  qualified based(pAferNull) end-ds;
```



The null-byte maps in trigger programs, 7.3

```
// Set the basing pointers using the offsets in the parameter
pBeforeBuf = %addr(parm) + parm.QDBORO;
pBeforeNull = %addr(parm) + parm.QDBORNBM;
pAfterBuf = %addr(parm) + parm.QDBNRO;
pAfterNull = %addr(parm) + parm.QDBNRNBM;
// Do some checking
if %nullind(afterDs.DUEDATE)
and afterDs.PRVBAL <> *zero and not %nullind(afterDs.PRVBAL);
```

```
sndEscapeMsg ('PRVBAL must be zero if DUEDATE is null');
endif;
```

7.3 only

You could also code the "IF" like this, but the relationship between the fields and their null-indicators may not be as clear

```
// Do some checking
if afterNull.DUEDATE
and afterDs.PRVBAL <> *zero and not afterNull.PRVBAL;
   sndEscapeMsg ('PRVBAL must be zero if DUEDATE is null');
endif;
```

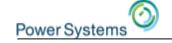


How could this support be improved?

Ideally ... in a perfect world ...

- RPG would understand that when a value was assigned to a field, it's null-indicator should be set off
- RPG would understand that it is nonsense to use a field if its null-indicator is on
- RPG and embedded SQL would understand each other's null-indicators

Maybe some day ...



RPG RFEs related to null-capable fields

There are some RFEs (Request for Enhancement) related to RPG and null-capable fields

- Option for EXTNAME/LIKEREC(*NULL) to create SQLtype int(5) indicator subfields (97462)
- Consistent use for null values (97341)
- Full NULL support (90098)

If you would like RPG's support for null-capable fields to be enhanced, vote for one or more of these RFEs

Use the "Comments" area to discuss the RFE



All RPG RFEs

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Here a link that lists all the RFEs for RPG:

http://ibm.biz/rpg_rfe

Or

- Go to <u>https://www.ibm.com/developerworks/rfe/</u>
- Click "Search"
- Check the "I want to specify the brand, product family, and product" option.
- Select

Product family: **Power Systems** Product: **IBM i** Component: **Languages - RPG** Brand: **Servers and System Software**



Creating an RPG RFE

If you don't find an existing RFE that describes what you want, open a new RFE:

- Go to <u>https://www.ibm.com/developerworks/rfe/</u>
- Click "Submit"
- Check the "I want to specify the brand, product family, and product" option.
- Select

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Product family: **Power Systems** Product: **IBM i** Component: **Languages - RPG** Brand: **Servers and System Software**

Make sure the headline is clear. You want to attract people to vote for your RFE.









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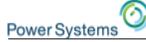
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