

**UNIFIED MODEL DOCUMENTATION PAPER**

**No. C7**

**UPDATING ANCILLARY AND BOUNDARY FIELDS  
IN THE ATMOSPHERE AND OCEAN MODELS**

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This version matches version 3.1 of the unified model

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Old Modification record.

- Version 6. Updated to match vn. 1.4 of the model. In particular includes effect of restructuring to allow use in the reconfiguration program.
- Version 7. Reset TSTAR to 0 C if snow created.
- Version 8. Major revision to ocean sections.
- Version 9. Revisions to field codes for orographic fields/ surface currents/ ice edge. Deletion of canopy water and ice surface temperature. Deletion of check against time in PP header. Inclusion of land-sea mask and orography in description of ancillary data sets. Restriction of lower boundary updating to orographic height. Correction to error code 4xx.
- Version 10. Updating of land-only fields. Removal of fix to set ICE\_FRACTION, ICE\_THICKNESS to specified values.
- Version 11. Major revision for atmospheric fields. Time interpolation for Gregorian calender corrected. Periodic data restricted to periods of 1 day, 1 month or 1 year. New error codes added: -5xx for time interpolation errors, 6xx for non-standard periodic data. Runoff coastal outflow point added. SST incrementing code removed and SST anomaly code added. Interpolation time value offset consistently by half update time interval.
- Version 12. Move heat convergence (slab) into atmosphere ancillary section.
- Version 13. Add orographic roughness into atmosphere ancillary section.
- Version 14. Add saturated soil water suction and soil moisture in layers to atmosphere ancillary section.
- Version 15. Add slab reference SST and ice depth

<b>Modification Record from version 16</b>		
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16		


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### 1. INTRODUCTION

There are a set of ancillary data sets and boundary data sets which can be accessed during a unified model run to update values held in the model dumps. These are treated as direct access data sets. The ancillary fields data sets can be used only to overwrite values held in the dump. Time interpolation, if needed, will be carried out by reading pairs of data sets and using a weighted mean of the two, the method is described in UMDP no. S1. One routine uses simple linear interpolation. The other allows for discontinuities caused, e.g., by changes in sea-ice extent. It makes use of the extra ancillary fields containing the time of change between a zero and a non-zero value at each point. The boundary data sets are held in two locations in the dump so that time tendencies can be generated and used to update model fields.

### 2. LIST OF ANCILLARY AND BOUNDARY DATA FILES

The ancillary fields that can be updated directly are listed in the Appendix, along with the logical file number of the ancillary data set. The data sets with FTN numbers and logical file numbers are listed here :-

Atmosphere ancillary fields (linear time interpolation used for fields marked \*, controlled linear time interpolation used for fields marked @. Note that fields marked # are produced from the ocean model in coupled mode and are therefore not then updated through the ancillary field system.)

FTN	File	
30	1	Ozone
31	2	Soil moisture(*) and snow depth(2), soil moisture in layers(*)
32*	3	Soil temperatures
33	4	Soil type fields
34	5	Vegetation type fields
35@#	6	Sea surface temperature
36@#	7	Sea-ice fields
38*#	8	Sea surface currents
39	9	Land-sea mask./ Runoff coastal outflow point
96	10	Orographic fields
59*	11	Heat convergence (slab)

Atmosphere boundary fields

95	Lateral boundary values for limited area model
96	Orographic values (including use for lower boundary condition for stratospheric model.)

Ocean ancillary fields (linear time interpolation used for fields marked \*. Note that fields marked # are produced from the atmosphere model in coupled mode and are not then updated through the ancillary field system.)

50#\* 1 Atmosphere wind and pressure forcing of ocean surface  
 51#\* 2 Atmosphere thermal forcing of ocean surface  
 52#\* 3 Water input to ocean surface.  
 53\* 4 Solar radiation over ice, snowfall(#) and sublimation(#).  
 54\* 5 Reference surface temperature and salinity, climatology of air temperature and ice depth.  
 56\* 6 Correction heat, salinity and ice depth (heat) fluxes  
 39 7 Land-sea mask.  
 99 8 Ocean depth

Ocean boundary fields

98 Lateral boundary values for limited area model  
 99 Ocean depth

**3. DATA SET FORMATS**

Each data set uses the standard format described in UMDP no. F3. It is important that FIXED\_HEADER(10) is correctly set to:- 0 for single time data, 1 for time series or 2 for periodic data. Also INTEGER\_CONSTS(3) should contain the number of different times of data e.g. 1 for single time, 12 for monthly periodic data, 6 for bi-monthly periodic data etc

The interval between data times in data sets containing several times must be regular and must be a whole number of hours for atmosphere fields. For boundary data sets an update interval in months or years can only be used with the 360 day calendar so that tendencies can be calculated. This restriction does not apply to ancillary data sets. Four level-dependent constants are set for ozone and lateral boundary data sets to define the hybrid levels at which the data is held. Data may be held at all levels at which ozone is held in the model dump, this must be consecutive subset of the model levels ending at the top of the model. One array of soil thicknesses is held for soil temperature data sets, and for data sets including soil moisture in layers.

All fields valid at a particular time are held consecutively in the data set. Not all the possible fields need to be included, but the same subset must be present at each time for which data is provided. e.g. most applications will not use ancillary files with both land-sea mask and runoff coastal outflow points.

Data other than lateral boundary values is held at all points in a horizontal field except that ozone may be held as a zonal mean. The fields contained in each record are as follows

Atmosphere ancillary fields

- 30 One field, either a zonal mean or a full three-dimensional field as specified in header. PP code 453, STASH code 60.
- 31 Either:-  
 Three two-dimensional fields (soil moisture, snowdepth, fractional time at which snow depth changes between zero and non-zero value between this data and the next time- the missing data indicator is used where there is no such change), held at all model grid-points. PP codes 106,93. STASH codes 21,23,27.  
 OR:-  
 The above plus soil moisture in layers. PP code 122, STASH code 9
- 32 Four two-dimensional fields to override all levels of the soil model. PP code 23, STASH code 20.
- 33 8 or 9 two-dimensional fields. (Volumetric soil moisture concentration at wilting point, volumetric soil moisture concentration at critical point, volumetric soil moisture concentration at field capacity, volumetric soil moisture concentration at saturation, saturated hydrological soil conductivity, exponent in the soil hydrological conductivity relationship, thermal capacity of the soil, thermal conductivity of the soil and, optionally, saturated soil water suction). PP codes

- 329,330,331,332,333,334,335,336,342. STASH codes 40-48.
- 34 8 two-dimensional fields. (Vegetation fraction, root depth, snow-free surface albedo, deep snow albedo, surface resistance to evaporation, surface capacity, infiltration enhancement factor, surface roughness length (determined by vegetation)). PP codes 326, 321, 322, 328, 323, 325, 327, 324. STASH codes 50-56, 26.
- 35 One two-dimensional field. PP code 16, STASH code 24.
- 36 3 two-dimensional fields. (Sea-ice fraction, fractional time at which ice fraction changes between zero and a non-zero value between this time and the next data time (the missing data indicator is used where there is no such change), sea-ice thickness). PP codes 37, 92. STASH codes 31, 38, 32.
- 38 Two two-dimensional fields. PP codes 701, 702.
- 39 One or two two-dimensional fields. STASH codes 30 and 93.
- 96 Up to 6 two-dimensional fields, always specified in metres or powers of metres. PP codes 1, 150, 152, 153, 154, 155. STASH codes 33, 34, 35, 36, 37, 19.
- 59 two-dimensional fields (heat convergence fields). PP code 620, STASH code 177.

#### Ocean ancillary fields

- 50 4 two-dimensional fields (Wind stress, x and y components, wind mixing energy, surface pressure). PP codes 721, 722, 627, 8
- 51 2 two-dimensional fields (solar heat flux, remaining heat flux). PP codes 625, 626.
- 52 3 two-dimensional fields (precipitation minus evaporation, river outflow, water type). PP codes 113, ?, ?.
- 53 3 two-dimensional fields (solar radiation over ice, snowfall, sublimation). PP codes 280, 103, 107.
- 54 4 two-dimensional fields (reference surface temperature, reference surface salinity, climatological air temperature, climatological ice depth). PP codes 601, 602, 16, 687.
- 56 3 two-dimensional fields (correction heat and salinity fluxes, ice depth correction). PP codes 676, 677, 678.

#### Atmosphere boundary fields

- 95 Northern boundary values for limited area atmospheric model, stored as  $p$ ,  $u$ ,  $v$ ,  $\theta_L$ ,  $q_T$ , tracers (a number of rows will be stored, as requested by the user); eastern boundary values, southern boundary values, western boundary values. Note that there is some duplication of values at the corners.
- 96 As under ancillary fields. Only the first field (orographic height) can be accessed by the boundary updating routine.

#### Ocean boundary fields

- 98 Lateral boundary values for limited area ocean model.
- 99 Ocean depth

## **4. CONTROL INFORMATION FOR UPDATING ANCILLARY AND BOUNDARY DATA**

When an initial data set is reconfigured (see UMDP no. S1), the ancillary data may be reset. This is controlled by a single code for each ancillary field, set to zero for no replacement and to 1 for replacement from the ancillary data set provided (using time interpolation as necessary as described in 2 above). Reconfiguration in this form is not available for the ocean model. If required a field of SST

anomalies will be created as the difference between the initial sea surface temperature field and the climatological values appropriate to the initial data-time ( time-interpolated from the ancillary files ). The anomaly field is stored in the D1 array and may then be used during the integration. Both of these functions are controlled by the LOGICAL,L\_SSTANOM which is set by the user interface.

When the integration starts, codes set by the user interface (one for each physical file) will be accessed to determine which files are required during the run. The fixed length, integer, real and all PP headers for each of the files required will be read in. Codes will be set by the user interface for each field to indicate how often a new record must be accessed. Not all fields contained within the physical file are necessarily updated at the same time. Codes will be set for every field that can potentially be updated, not just the ones that actually are being updated. Where the time interpolation of one field depends on the values of a second field, e.g. sea surface temperature and sea-ice, then an update of the second field will be requested automatically when the first is updated. Details are given in section 5.

### Ancillary data

#### First code

- 0 Do not update (initial value in start field retained indefinitely, or model allowed to prognose its own field).
- 1 Update interval defined in years
- 2 Update interval defined in months
- 3 Update interval defined in days
- 4 Update interval defined in hours

In cases 1 and 2, the check is performed each day and uses the model calendar to detect the beginning of a month or year. A mixture of years/months with days/hours can only be specified if the 360 day calendar is used.

#### Second code

- n Replace data every n intervals

#### Boundary data (one code only)

- 0 Do not update
- 1 Update at interval specified by boundary data sets.

Updating ceases after the time in the last data set (e.g. allowing orography to be grown for a limited period only), and the integration will then proceed with zero tendencies. If the last lateral boundary data is reached the model will abort if the integration attempts to continue past its validity time.

## **5. UPDATING ANCILLARY AND BOUNDARY DATA IN THE MODEL**

At the prescribed time interval, a PP header or headers (according to whether time interpolation is required for the field being updated) are accessed using the time information in the fixed length header. The PP header defines the position of the data in the physical file, which is then read. The action then depends on the field, and is described by physical file number

#### Atmosphere ancillary fields

- 30 The field in the dump image is completely overwritten. No time interpolation.
- 31 The snow depth is interpolated in time allowing for the time of onset or cessation of snow

cover. TSTAR is reduced to a maximum of 0°C if snow is present. The soil moisture is linearly interpolated in time, compressed to land points, and updated. No checks between the land-sea mask in the model and that implied by missing data indicators in the data are performed.

32-34 The corresponding field in the dump image is compressed to land points and overwritten. No time interpolation.

35 Controlled time interpolation performed allowing for the onset or cessation of sea-ice cover. TSTAR is then overwritten where LAND=.FALSE. and ICE\_FRACTION=0..

36 Controlled time interpolation performed allowing for the onset or cessation of sea-ice cover. The ice-fraction and ice thickness values in the dump image are then overwritten. If the ice fraction (ICE\_FRACTION) is increased from zero to a non-zero value, TSTAR is replaced by TFS. If it is decreased to zero, TSTAR is replaced by a sea-temperature value from file number 35. These dependencies require sea temperatures to be updated whenever sea-ice is updated.

39,96 The new fields replace the old. Additional adjustments are made to other model fields as described in UMDP no. S2.

59 Corresponding field in the dump image overwritten, with linear time interpolation.

#### Ocean ancillary fields

50-54,56 Corresponding fields in the dump image overwritten, with linear time interpolation.

39,99 Updating of these fields is not yet available.

#### Atmosphere boundary fields

95 At the start of the run, two records are read. The initial data time is checked to lie between the validity times of the first and last lateral boundary data times and aborts if not. Pointers are set to locate the values of the prognostic variables required, and a mismatch between the boundary and initial data variables will cause a failure. Variables, levels and rimwidth sizes are all checked for consistency. This checking is not performed again after this time. Tendencies (per boundary data interval) are calculated. The tendencies and the second set of values are stored in the dump image. At the next update interval another record is read, and a new set of tendencies calculated.

96 As 95, except that there are a fixed number of variables so no checking is performed.

#### Ocean boundary fields

98 As 95

99 As 96.

## **6. CONTROL INFORMATION**

The following input data has to be set for both updates in the reconfiguration and in the model.

### COMDECK CANCELA

NANCIL\_LOOKUPSA      Number of PP headers describing atmospheric ancillary data allowing one for each time.

### COMDECK CANCELLO

NANCIL\_LOOKUPSO      As above for ocean ancillary data.

The following control information applies only to updating within the model.

## COMDECK CBOUND

RIMWIDTHA Width of zone for which lateral boundary data provided (atmosphere).  
RIMWIDTHO As above (ocean)  
FLOORFLDSA Number of atmospheric lower boundary update fields provided at each time.  
FLOORFLDSO As above (ocean)  
NRIM\_TIMESA Number of times for which atmospheric lateral boundary data provided.  
NRIM\_TIMESO As above (ocean)  
NFLOOR\_TIMESA Number of times for which atmospheric lower boundary data provided.  
NFLOOR\_TIMESO As above (ocean).

## NAMelist &ANCILCTA

FIELDcode(2,NANCIL\_FIELDsA),L\_SSTANOM

Two codes for each field as described in section 4 and switch for SST anomaly.

## NAMelist &ANCILCTO

FIELDcode(2,NANCIL\_FIELDS)

Two codes for each field as described in section 4.

## NAMelist &BOUNCNST

BOUND\_FIELDcode(2+FLOORFLDSA+FLOORFLDSO)

One code for each field as described in section 4.

RIMWEIGHTsA(RIMWIDTHA)

Weights to be used in merging data in boundary zone.

RIMWEIGHTsO(RIMWIDTHO)

As above (ocean)

Additional control information for updating in the reconfiguration consists of setting FIELDcode(NANCIL\_FIELDsA) in a reconfiguration namelist (UMDP no. S1).

## 7. MESSAGES, ERROR CODES AND ACTIONS

### Messages from INANCILA and INANCILO routines:

A summary of the header information is printed for each data set from which an ancillary or boundary field is requested.

### REPLANCA routine:

A message 'UPDATE REQUIRED FOR FIELD n' is generated for each field requested, or for additional fields requested automatically because of dependencies.

A message 'Information used in checking ancillary data set' then appears, followed by:

- \* position of lookup table in set of lookup tables for the data set being read.
- \* position of first lookup table referring to appropriate type of data.
- \* interval between lookup tables referring to same data type at same level.
- \* number of these intervals to be skipped forward to reach correct data time.
- \* STASH code in data set and STASH code requested.
- \* Start position in model lookup array of lookup table for current data set.
- \* A mismatch in STASHcodes will cause failure, the other information printed out above should enable the failure to be traced.

### Error messages

Codes 0-99 I/O errors and format errors in input data sets. Details in code and error messages.

Codes 1xx End of data when reading first data time for STASHcode xx.

Codes 2xx STASHcode in PP header does not contain expected value.

Codes 3xx End of data when reading second record. If end of data is encountered when reading a second record for time interpolation, the data is assumed periodic and the first record is read instead. If this failure message occurs in a periodic data set it then indicates an I/O error or another more serious problem with the file.

Codes 4xx Data time before start time of non-periodic data set.

Codes 5xx Time interpolation error. Interpolation time lies outside interval given by two validity times of data used for interpolation.

Codes 6xx Non-standard periodic data. Code only available for periods of 1 day, 1 month or 1 year. Most likely INTEGER\_CONSTS(3) not set since this is used to determine the period.

**APPENDIX 1**

List of ancillary fields that can be updated directly

No in field-code array/ logical file number

Atmosphere

1	9	Land-sea mask
2	10	Orography
3	10	Orographic standard deviation
4	10	Orographic gradient xx component.
5	10	Orographic gradient xy component.
6	10	Orographic gradient yy component.
7	1	Ozone
8	2	Soil moisture
9	2	Snow depth
10	3	Deep soil temperature
11	4	Volumetric soil moisture concentration at wilting point
12	4	Volumetric soil moisture concentration at critical point
13	4	Volumetric soil moisture concentration at field capacity
14	4	Volumetric soil moisture concentration at saturation
15	4	Saturated hydrological soil conductivity
16	4	Eagleson's exponent.
17	4	Thermal capacity of soil
18	4	Thermal conductivity of soil
19	5	Vegetation fraction
20	5	Root depth
21	5	Snow-free surface albedo
22	5	Asymptotic deep snow albedo
23	5	Stomatal resistance to evaporation
24	5	Canopy capacity
25	5	Soil infiltration enhancement factor
26	5	Surface roughness
27	7	Sea-ice fraction
28	6	Sea-surface temperature
29	7	Sea-ice thickness
30	8	Sea-surface zonal current
31	8	Sea-surface meridional current
32	9	Runoff coastal outflow point
33	11	Heat convergence (slab)
34	10	Orographic roughness
35	4	Saturated soil water suction
36	2	Soil moisture in layers
37	6	Slab reference SST
38	7	Slab reference ice depth

No in field-code array/ logical file number

Ocean

1	7	Land-sea mask
2	8	Ocean depth
3	1	Zonal wind stress
4	1	Meridional wind stress
5	1	Wind mixing energy
6	1	Surface pressure
7	2	Solar heat flux at sea-surface
8	2	Remaining heat flux at sea-surface
9	3	Precipitation minus evaporation
10	3	River outflow
11	3	Water type
12	4	Solar radiation over ice

13	4	Snowfall
14	4	Sublimation
15	5	Climatological ice depth
16	5	Reference surface temperature
17	5	Reference surface salinity
18	5	Climatology of air temperature
19	6	Anomalous heat flux
20	6	Anomalous salinity flux
21	6	Ice depth correction (heat)

## FILE STRUCTURE OF LATERAL BOUNDARY DATA.

1. This information is extracted from the following Unified Model source decks, which see for more details:-

Deck	Subroutine	Purpose
ININTF1	IN_INTF	Sets up and writes out headers.
INTFCTL1	INTF_CTL	Compute lengths.
INTFHIC1	INTF_HINTC	Compute interpolation coefficients for extracting boundary data.
GENINTF1	GEN_INTF_A	Generates and writes out boundary data field.

The following decks which read and apply the lateral boundary data may also be useful.

INBOUND1	IN_BOUND	Reads in and checks headers of boundary data.
UPBOUND1	UP_BOUND	Reads in boundary data field.
CHKLKBA1	CHK_LOOK_BOUNDA	Checks LOOKUP header.
BOUNDVA1	BOUNDVAL	Updates lateral boundary values.
MERGFLD1	MERGEFLD	Weighted merge of boundary data with model values in boundary zone.

Note, this list may not be complete.

2. HEADERS.

Boundary data files use the same standard format as other UM files, as described in UM Documentation Paper no. F3. Items with specific values/meanings in boundary data files are as follows:-

FIXED_LENGTH_HEADER - FIXHD - Dimension 256	
FIXHD(5) = 5	indicator for <b>boundary</b> data.
FIXHD(10) = 1	indicator for <b>time series</b> data.
FIXHD(21-27)	<b>first</b> validity time of boundary data.
FIXHD(28-34)	<b>last</b> validity time of boundary data.
FIXHD(35-41)	<b>interval</b> between validity times of boundary data.
FIXHD(152)	number of pp headers in LOOKUP (see below).

INTEGER\_CONSTANTS - INTHD- Dimension 15

INTHD(3)	number of different times for which data are present.
INTHD(6-9)	see UMDP F3 - values refer to model to <b>use</b> data.
INTHD(15) = 5	number of different field types present, assuming no tracers.

REAL\_CONSTANTS - REALHD - Dimension 6

These should be for the domain of the model that will use these boundary data.

LEVEL\_DEPENDENT\_CONSTANTS - LEVDEPC

1st Dimension = maximum number of levels at which data are present = P\_LEVELS of model to use data.

2nd Dimension = 4, for AK, BK, DELTA\_AK, DELTA\_BK specifying vertical levels at which data are stored.

LOOKUP table.

1st Dimension = 64 for standard 64 word pp header.

2nd Dimension = INTHD(3) \* INTHD(15) = number of times for which data are present \* number of field types. Note, this is an exception to the standard, as the boundary data for each time are written as a single field containing data for all levels and variables, see section 3. Thus, although the actual number of fields of data is INTHD(3), the number of pp headers in LOOKUP is not INTHD(3) but INTHD(3)\*INTHD(15), and this is required for correct use of boundary data.

3. DATA.

For each validity time, all boundary data are contained in a single field, concatenated in a specific order, as programmed in the model (see decks INTFHIC1 & GENINTF1), and accessed

using a carefully incremented pointer.

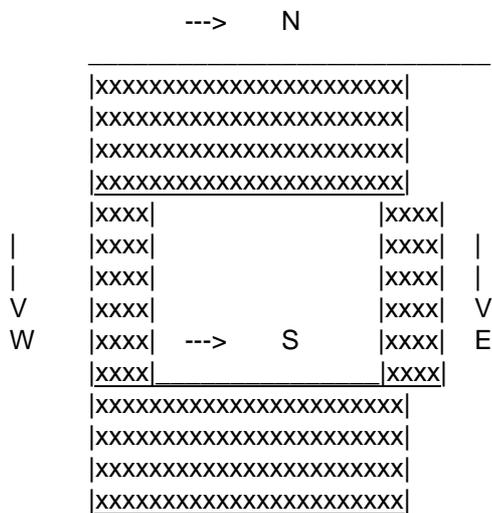
Within each field, data are stored for the 5 variables, p, u, v,  $\theta_L$  &  $q_T$ , as follows:-  
 1 p-grid boundary zone for surface pressure, P\_STAR, (Pascal)  
 P\_LEVELS u-grid boundary zones for u-component wind, U, ( $\text{ms}^{-1}$ )  
 P\_LEVELS u-grid boundary zones for v-component wind, V, ( $\text{ms}^{-1}$ )  
 P\_LEVELS p-grid boundary zones for liquid water potential temperature, THETAL, (K)  
 Q\_LEVELS p-grid boundary zones for total water, QT, ( $\text{kgkg}^{-1}$ )  
 [Tracers are not used operationally]  
 where P\_LEVELS is the total number of levels in the model to use the boundary data and  
 Q\_LEVELS is the number of 'wet' levels. For the Arakawa B-grid scheme used by the Unified  
 Model, p-grid signifies data on pressure points, while u-grid signifies wind points which are  
 displaced by half gridlengths East & South.

The width in gridpoints of the boundary zone is specified as INTFWIDTHA, and normally a  
 value of 4 is used. Within each boundary zone, data are stored in 4 rectangular segments covering  
 North, East, South & West boundary points, in that order. **Note that**, contrary to what UMDP C7  
 section 3 currently says about 'Atmosphere boundary fields', there is no duplication of values at the  
 corners. Rather the East & West segments are shortened by omitting the northmost & southmost  
 rows, see Fig. 1. Throughout all 4 segments of the boundary zone, data are extracted by rows  
 (West to East) running from North to South, even for the East & West segments where the rows are  
 only INTFWIDTHA points long. Thus the number of points in the boundary zone is:-  
 (ROW\_LENGTH + P\_ROWS - 2\*INTFWIDTHA) \* 2 \* INTFWIDTHA for the p-grid and  
 4 \* INTFWIDTHA fewer for the u-grid.

For the u-grid the eastmost column of wind values is ignored in extracting boundary data  
 and is not updated, while the southmost row does not exist for fields on the u-grid, so that for all 4  
 sides of the boundary zone values on the u-grid are half a gridlength inside the p-grid.

To reduce file size, the model writes, stores and reads the boundary data (but not the file  
 headers) as 32-bit numbers.

Fig. 1.



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