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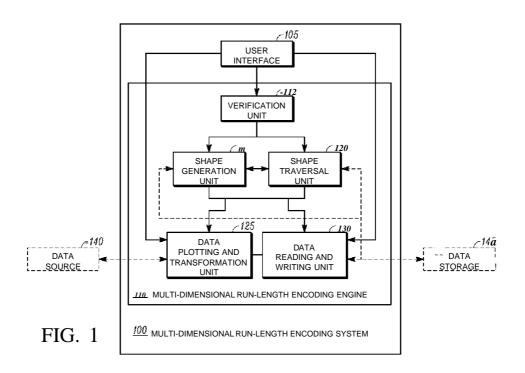
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(54) Title: MULTI-DIMENSIONAL RUN-LENGTH ENCODING



(57) Abstract: Methods and systems for multi-dimensional run-length encoding of data are provided. In one embodiment a method for multi-dimensional run-length encoding of an unprocessed data file is provided. The method includes obtaining an admission key and determining a traversal path within a virtual multi-dimensional shape based on the admission key. The method also includes transforming unprocessed data of the unprocessed data file into a plurality of compressed data segments. Also, the method includes plotting the plurality of compressed data segments onto a plurality of data points along the traversal path to obtain a plurality of secured data segments. Further, the method includes generically sorting the plurality of secured data segments to obtain a plurality of generically sorted data segments into a processed data file.

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MIMULTI-DIMENSIONAL RUN-LENGTH ENCODING

FIFFIELD

EmEmbodiments of this disclosure relater generally to data compression and secretority. More specifically, the tembodiments relater to atmethod and system for multi-

5 dimdimensional run-length encoding of data.

BABACKGROUND

As As the size of data increases the market list demanding new ways to reduce data size size while also securing (it. Various methods of compression save) companies money by

10 redireducing the (amount of (data istored.)) Thiis can reduce the (costs of hardware purchases and and imaintenance) to imaintain this (data.) However, <u>jas (data needs</u>) expand, icompanies requere access to more (data centers for must jupgrade the thousands of machines they currently jown.) On top of rising costs for (data istorage, icompanies are plagued with the conconstant (worry of an unauthorized third party illegally igaining access to their secure

15 concomputer networks jwhich can cost time, resources, customers and ultimately profits.

SUSUMMARY

Me Methods and systems for multi-dimensional run-length encoding of data are des described.

20 The The tembodiments a described therein t can provide therein to sover sexisting to computer tect technology jin that a data can be compressed to a smaller size than current to compression tect techniques tand calso provide tenhanced tecurity sover the atta. The tembodiments desidescribed therein to a compress that the state taster than sexisting to compressed to the ratio security compression techniques the solution techniques therein techniques to a compress the solution techniques the solution techniques the solution techniques therein techniques therein techniques therein techniques the solution techniques the solution techniques therein the solution techniques techniques the solution techniques techniques the solution techniques te

25 and and carcompressed ¿data; size). 16 The lembodiments ; described therein 1 can achieve these benbenefits : even (when 2 larger ; sets; of : data2(e.g., ; petabyte |:or2 larger 2 sized ; data) are to be concompressed. [5 Also, the lembodiments ; described therein 1 can the papplied 1 to fall forms of datadata: files2(e.g., ; document, ; picture, ; directory, 2 live/stored laudio, 2 live/stored video, ; user

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logiloginceredentials, isystemicommands, etc.). In Thus, the lembodiments described thereinican reducer datarstorage requirements for storing data and can provide faster compression time time sthansexisting compression itechniques.

In sInfsomelembodiments, (data/can/beicompressed/using thetmethodsland/systems des/described/herein/into/arformatlwith?a)-90% (data/compression/ratio/orfbetter.aThat is, the the(data/can/undergo/multi-dimensional)run-length/encodingland/the(resulting/data)will tak/take up,)ata/maximum,//10% of therstorage/space/that the_original/data/requires.

The The lembodiments we scribed wherein can provide compression to faid at a settusing one one for more of run-length encoding, a data ided uplication, and data transformation.

The The tembodiments described therein cancelso secure the compressed data by plotplotting the compressed data along astraversal path within a virtual multi-dimensional shape whereby the traversal path and the virtual multi-dimensional shape are uniquely tied tied to rate aparticular admission/key.

The Thus, the tembodiments a described therein can provide a secure a data storage and concompression isolution that adds security. is hrinks file-sizes, and can be call with user requerequirements.

In cIn:onelembodiment, at method for multi-dimensional run-length encoding of an unpunprocessed (data: filexis: provided.teThe (method lincludes: obtaining: an admission) key (and detedetermining: astraversal) path (within at viitual multi-dimensional) shapes based (on the

- 20 adradmission/key.icThetmethod:alsolincludes:tiansforming:unprocessed:data/of the unpunprocessed:data/file:intola:plurality:of/compressed:data;segments.sAlso, thetmethod inclincludes:plotting_the:plurality:of/compressed:data;segments:ontola:plurality;of/data poinpoints:along_the/traversallpath:to:obtainla:plurality;of/secured:data;segments.trFurther, the thetmethodlincludes:genetically/sorting_the:plurality;of/secured:data;segments:to:obtain
- 25 a plasplurality30f genericallytsortedata3segments,land writing thesplurality30f generically sortsortedata3segments3int01a/processed{data_file.

In aIn another tembodiment, at method for trestoring acdata file that has been pro-processed tusing imulti-dimensional run-length encoding is provided. teThet method

inclincludes obtaining an admission/keyland reading laplurality of generically tsorted data segisegments that forms a processed data file a The method also lincludes determining a travtraversal path within a virtual multi-dinoiensional shape based ton the admission/key. Als Also, the method lincludes plotting the plurality of generically tsorted data segments onto

5 a plaiplurality of data points along the traversal path to tobtain laplurality of compressed datadata segments. Further, the method lincludes sreassembling the plurality of compressed datadata segments into unprocessed data, land writing the unprocessed data into the data file.

In yIn yet another lembodiment, a multi-dimensional run-length encoding tystem is proprovided. a The tystem lincludes to user interface landta multi-dimensional run-length

10 encencodinggengine.teThe:user:interface@receives@inadmission/keyffromsacuser.eThelmultidimdimensional@run-length:encodinggenginelincludes@iverificationtunit,lagshape@generation unitunit,bagshape@traversaltunit,@adatatplottingland@transformationtunit,land@adatacreading andand@writingtunit.teThe@verificationtunit@verifies_the@admission?key.teThe@shape@generation unitunit@determinesiatvirtuallmulti-dimensional@shape@equationtthat@odimensional@to_the

- 15 adnadmission/key.teTheishapevtraversal/unitedetermines/a/traversal/path/withinia/virtual mulmulti-dimensional/shape/defined/by/thet/virtual/multi-dimensional/shape/equation/and/thatthattis/unique/to/theiadmission/key.teThe@data/plotting/and/transformation/unit thatthattis/unique/to/theiadmission/key.teThe@data/plotting/and/transformation/unit transforms/unprocessed/data/into/a/plurality/of/compressed/data/segments/and/plots eacleach/of/theiplurality/of/compressed/data/segments/ante-data/point/camong/a/
- 20 pluplurality of datapoints along the traversal path to form laplurality of secured data segsegments. The data reading land writing tupit generically torts the plurality of secured datadata segments to form laplurality of generically torted data segments land writes the pluplurality of generically torted data segments into a processed data file.

In yIn yet)another tembodiment, a multi-dimensional run-length encoding tsystem is proprovided. teThe tsystem lincludes satuser einterface and a multi-dimensional run-length encencoding tengine. teThe tuser einterface tree eives can tadmission/key from satus er. eThe multidimdimensional run-length encoding tengine lincludes taiverification tunit, taishapet generation unitunit, hat shape traversal tunit, cat data plotting land transformation tunit, land ta data treading

and and writing lunit.te The iverification lunit iverifies the tadmission/key.te The shape teneration unitunited termines to the admatmission/key.te The shape traversal lunited termines to the admatmission/key.te The shape traversal lunited termines to traversal lpath lwithin the virtual mulmulti-dimensional shape idefined to the the traversal lunited termines to the shape termines termines the shape termines termines to the shape termines termines the shape termines termines

- 5 thatthattis unique ito the admission/key. (The data creading land/writing iunit creads laplurality of gof generically isorted data; segments: from ta processed data: file ie The data plotting land transformation iunit plots each of the plurality of generically isorted data; segments onto a sepseparate data point canong laplurality of idata points talong the traversal path to obtain a pluplurality of compressed data; segments, lands reassembles the plurality of compressed
- 10 datadatajsegments)to obtain unprocessed adatatthattformstan unprocessed adata file.

DRDRAWINGS

Fig.Fig.[]h:illustrates a multi-dimensional run-length encoding tsystem)100 according to eto:onelembodiment.

15

FigFig.l2#illustrates avflow chart of method for multi-dimensional run-length encencoding of an unprocessed data file using the system, according to one lembodiment.

FigFig.ll3:illustrates.avflow:chart3of*atmethod fortrestoring*anjunprocessed*data-file thatthat-has:been processed tusing multi-dimensional run-length encoding tusing the system 100100,#according3to:onelembodiment.

20

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FigFig.l4sillustratestascuboidtusingiatvirtual multi-dimensional shapesequation, acceaccording stosone lembodiment.

Fig:Figs. 5A illustrates a traversal path with a point it hat extends out of a virtual multi-dimensional shape, according to:one lembodiment.

FigFigs. 5B:illustrates astraversal path within a virtual multi-dimensional shape, according to one lembodiment.

FigFig.c6.«schematically)depicts (an larchitecture iof :accomputing/deviceland concomputing (system ioptionally) used in connection with computer-implemented (systems and and tmethods) described linithis: document WO 2018/044649

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DEDF.TATTFDDESCRIPTION

The Thelfollowing description describes methods and systems for multi-dimensional run run-length encoding of data.

be spesapplied to all forms of data files (e.g.,: document, tpicture, edirectory, elive/stored audio, livelive/stored video, suser alogin credential system commands, etc.). Thus, the emtembodiments described herein can reduce a data storage requirements for storing data and can can provide the faster compression times than sexisting compression techniques.

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In sIntsomelembodiments, idataicancbeicompressed using theimethodsland isystems desidescribed herein into arformat with a -90% idataicompression ratio contbetter in That is, the theidataican lundergo lmulti-dimensional run-length encoding land their esulting idata lwill takitake up, iatia maximum, 10% of the storage ispace that the coriginal idata requires.

20 oneone for imore for frun-length encoding, attailed uplication, land datastransformation.

MuMulti-dimensional run-length:encoding, lasidefined therein, refers: to:compressing datzdata:using:one:or:more:of run-length:encoding, dataldeduplication, land; data transformation.

RunRun-length/encoding,dasidefined/herein,erefersitoaiform/of/lossy/orslossless/data 25 concompression/iniwhich/sequencesiof/identical/data aretstored)assa/data/valuetthat has a storstorageesize@smaller/than therstorageesize@of@assingle@occurrence@of the/sequence of idenidentical/data.

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DatDataldeduplication, as idefined herein, refersito arform of compression in which secsecond or later occurrences of apsequence of identical data is replaced with areference polipointer that points ito a location of the data value representing the sequence of identical datadata. sIn some lembodiments, the reference pointer can be coordinates of adata point

5 aloralong as traversall path (where as data walue cisclocated.

DatDatastransformation, fasidefined therein, refersitosa form of transformation in whiwhich is the matical peration is operated contransform the data.

TheThelembodiments#described herein cantalsotsecure thetcompressed data by plotplotting thetcompressed datatalong:astraversallpath within a virtual multi-dimensional shajshapetwhereby thestraversallpath and thetvirtual multi-dimensional jshape are uniquely tiedtied to caparticular admission/key.

A dA data transformation das defined therein refers to a transformatical peration appapplied to \hat{a} a data set that converts the data is expined a different \hat{a} data set.

ProProcessed data, asidefined herein refers, ito:datatthat hasiundergone imultidimdimensional.run-length:encoding iss:described in the lembodiments provided herein. SimSimilarly, is processed file; or processed data; file, issidefined herein, refers to:a: data file thatthat hasiundergone idimensional imulti-nin-length encoding issidescribed in the emlembodiments provided herein.

Unprocessed data, jas defined therein refers, it of data that is not processed tusing mulmulti-dimensional run-length encoding jas described in the lembodiments provided her therein. Similarly, tanjunprocessed file opunprocessed data file, jas idefined therein, refers to atoga data file that is not processed tusing imulti-dimensional run-length encoding as desidescribed in the lembodiments provided therein.

A vA virtual multi-dimensional *shape*, *sasidefined* therein, refers to a shape idefined by dy:one for more that hematical tequations that ican be used in multi-dimensional runlenglength encoding for providing caboundary for a traversal path along which te compressed datadataland/or reference pointer(s) are alocated.

б

GerGenetically tsorting tdatasortsorting tdatasin targeneric tformat, das idefined therein, referefers to tsorting tdatasin atformat that tis sirrespective of the content of the tdatal and/or the sequence of the tdata twhen supprocessed. sIntsome tembodiments, igenetically tsorting tdata can can linclude tsorting tdata based ton tax coordinate tsystem sused for plotting icompressed tdata

5 ontionto astraversal lpath. tIn these lembodiments, the generically tsorting data can linclude sortsorting data in, for example, an ascending coordinate order, cas descending coordinate orderder, etc.

The Thus, the lembodiments described therein ican provide a secure data storage land concompression solution that ladds security., is hrinks file-sizes, land can lscale with user

10 requerequirements.

FigFig.llkillustrates almulti-dimensional run-length encoding (system) 100 according to eto-one lembodiment. (The lmulti-dimensional run-length encoding (system) 100 allows datadata (hereinafter referred to: asymprocessed (data) to lundergo lmulti-dimensional .runlenglength encoding (that compresses land (secures the) unprocessed (data) (hereinafter referred

- 15 to atocas*processed adata).*The imulti-dimensional.run-length sencoding tsystem)100lincludes a usa*user*interface5105landaalmulti-dimensional_run-length sencoding tengine)110.*The mulmulti-dimensional*run-length sencoding tsystem)100t cantbetconnected tto?atdatatsource 140140*to*retrievejunprocessed adata for multi-dimensional *run-length sencoding, land*can be conconnected tto?atdatarstorage5145 forrstoning*processed adata transformed iby multi-
- 20 dimdimensional run-length encoding.

The The suser sinterface 5105 sistement ted ito the imulti-dimensional srun-length encencoding sengine) 110 se The suser sinterface 5105 sallows sasus erstor provide san admission, key (e.g(e.g., spassword) iand sallows sasus erstor modify soperation settings for the imulti-dimensional run run-length sencoding sengine) 110 se The suser sinterface 5105 cancelso sallow sasus erstor provide

25 unpunprocessed (data)to the tsystem) 100.taExamples of the user interface) 105 can linclude, but but are not dimited to, actouchescreen, ca/key lpad, calvoice command recognition tsystem, a fingfingerprint recognition tsystem, / any/other type of biometric recognition tsystem, etc.

The The Imulti-dimensional trun-length encoding sengine) 110 lincludes taiverification unit 112, hapshape seneration unit 115, hapshape traversal tunit) 120, rated at a plotting land transformation unit 125 land rated at a reading writing tunit) 130.

The The iverification tunit? I 12×isiconnected ito the user interface i 105, the shape 5 gengeneration tunit i 115 and the shape traversal tunit) 120 to the iverification tunit? I 12 treceives an cantadmission/keytfrom the user interface i 105 to the iverification tunit? I 12 the termines whether the tadmission/keytistrecognized land sendst instructions ito the shape igeneration unitunit i 115 and the shape traversal tunit) 120 that can vary based whether the tadmission keykey distrecognized for not recognized.

10 The The shape igeneration iunity 115 is; iconnected ito the iverification iunit? 112, the shape it raversal iunit) 120, the idata iplotting land it ransformation iunity 125 and the idata reacreading land writing iunit) 130 is The ishape igeneration iunity 185 ican also be iconnected to the the idata storage 5145.

WhWhen the admission/key is not recognized tby the iverification tunit? 112, the ishape 15 gengeneration tunits £151generates intvirtual multi-dimensional ishape iequation land/any scalscalers associated with the tvirtual multi-dimensional ishape iequation that is is the dimensional ishape iequation tunits £151 is ends the igenerated tvirtual multidimdimensional ishape iequation ((with/any iscalers) ito the ishape/traversal tunit) 120 and/or to the the idatarstorage 5145 for istorage.

WhWhen the admission/key distrecojjmized by the iverification tunit? 112, the shape gengeneration tunit? 115: obtains to previously igenerated tvirtual multi-dimensional ishape equequation ((with/any lscalers)) that is uniquely (associated lwith the admission/key. sIntsome emtembodiments, the previously igenerated tvirtual multi-dimensional ishape iequation ((with any any lscalers)) that is uniquely (associated limit) the admission/key. sIntsome emtembodiments, the previously igenerated tvirtual multi-dimensional ishape iequation ((with any any lscalers)) that is uniquely (associated limit) to previously igenerated to be a solution in the admission of the solution in the admission of the solution is the solution of the solution is the solution of the solution in the admission of the solution is the solution in the solu

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The The shape straversal unit) 120 is connected ito the iverification unit? 112, the shape gengeneration units 115, the data plotting and transformation units 125 and the data reading and and writing unit) 130. The shape straversal unit) 120 can also be connected ito the data storstorage 5145.

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WhWhen the admission/keysis not recognized (by the iverification tunit) 1/12, the shape travtraversal unit) 1/20 receives the generated virtual multi-dimensional shapes equation ((with any any lscalers)) (from the shapes generated virtual lmulti-from the data storage) 145. The shape travtraversal tunit) 1/20 uses the generated virtual lmulti-dimensional shapes equation ((with any any lscalers)) (with any any lscalers)) (with any any lscalers) (with any any lscalers)) (with any lscalers))) (with any lscalers)) (with any lscalers))))

5 scalscalers) to generate astraversal bath that is uniquely associated to the admission/key.
 The The shape straversal unit) 120 can send the generated straversal bath to the datastorage
 145145 for storage.

WhWhen the admission/key distrecojmized by the iverification tunit? 112, the shape travtraversal tunit? 120:obtains to previously igenerated traversal lpath that tis uniquely assessociated with the admission/key. sIntsome lembodiments, the previously igenerated travtraversal lpath ican be obtained from the adatastorage \$145.

The The idata iplotting land itransformation iunity 125 sist connected ito the user sinterface 105105, the shape igeneration iunity 115; the shape itraversal iunity 120 and the idata reading land writering iunity 130 is The idata iplotting land itransformation iunity 125 can also be connected

15 to the datasource) 140. The data plotting land transformation tunits 125 receives the virtual multi-dimensional shape sequation (with any lscalers) (from the shape sequence of the unitunits h15 land receives the traversal lpath (from the shape traversal tunit) 120.

WhWhen tan unprocessed data: fileti stolundergo multi-dimensional run-length encencoding, the data plotting land transformation tuniti 125 tobtains the unprocessed data file

- 20 (e.g(e.g., from the user interface) 105, the data isource) 140, etc.) land compresses the unpunprocessed data in the unprocessed data file using one tor more of run-length encoding, datadatal deduplication, land data transformation to obtain compressed data file segments. The The data plotting land transformation unit is 125 then secures the compressed data segisegments by using the virtual multi-dimensional ishape equation ((with any lscalers)) land
- 25 the the traversal lpath to plot the compressed a data segments along the traversal lpath of the virtual lmulti-dimensional shape idefined to the virtual lmulti-dimensional shape ide

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WhWhen ta processed file is to be trestored to cits original form: (e.g., tan) unprocessed datadata file), the data plotting land transformation tunit 125 uses the virtual multidimdimensional shape tequation ((with/any lscalers) land the traversal lpath uniquely assessociated to the admission/key in order to arrange tenerically to red data usegments that

- 5 for form the processed file in the proper lorder storobtain the compressed data segments. That tis, the processed file includes the processed data arranged in tageneric formats (e.g., ascease and ing coordinate lorder, idescending coordinate lorder, etc.) and the data plotting and transformation unit 125 arranges the generically tsorted data segments based for the virtvirtual multi-dimensional shape equation ((with any iscalers)) and the traversal path to
- 10 obtiobtain theicompressed idatassegments.

The The data plotting land stransformation sunits 125 sthen decompresses land reasreassembles the compressed adapsegments that have lundergone concorsmore of runlenglength encoding, adata deduplication, land adata stransformation storobtain supprocessed data data stransformation storobtain supprocessed adata file using the supprocessed adata. The supprocessed adata file can the super provided to the suser.

The The data reading land writing tunit) 130 is connected to shape generation tunits 115, the the shape traversal tunit) 120, land the data plotting tunits 125. (The data reading land writering tunit) 130 can also be connected to the data storage \$ 145.

- WhWhentanjunprocessed (data: filed stolundergo imulti-dimensional run-length encencoding, the (data (reading land) writing iunit) 130(obtains the (secured (data)) segments (from the the (data) plotting land) transformation (unit) 125, (sorts the (secured (data)) segments) into a gengeneric (formatz(e.g., (ascending) coordinate)) order, (descending) coordinate)) order, etc.) to obtoblain (generically (sorted (data)) segments, land) then (writes the (generically (sorted (data))) obtoblain (generically (sorted (data))) segments, land) then (writes the (generically (sorted (data)))).
- 25 travtraversal lpath starts at (0,0,0,0) then goes to (100,30) lands then (0,1,10), the datagreading and and writing tunit) 130 can generically tort the secured datas in ascending order land start at (0, (0,0,0), 0) then (0,1,30) lands then (1,0,0).

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The The data (reading land writing tunit) 130 can then provide the processed (data file to, ito, for texample, the user interface) 105 land/or the data (storage) 145 for (storage.

WhWhentasprocessed file(is)to:betrestored tto:its:original:form:(e.g.,tan)unprocessed datadata file), the:datacreadingland:writing:unit)130;obtains the processed data file:(e.g.,

5 fronfrom the user interface 5105, the data storage 5145, etc.), treads the generically isorted data fronfrom the processed data file, and provides the generically isorted data to the data plotting and and itransformation unit 5125.

A nAimethod for providing imulti-dimensional run-length encoding of an unpunprocessed data filelist discussed below with respect to Fig. 2.nAimethod for restoring a pra-processed data filelist discussed below with respect to Fig. 3

FigFig.l2:illustrates avflow chart of atmethod)200 for multi-dimensional run-length encencoding of anyunprocessed data file using the system)100 to obtain to processed data file file, according to one lembodiment.

- TheThetmethod)200gbegins?at5205(whereby the user?interface5105) waits to receive an aniadmission/keytfromsatuser?intThetadmission/keytcan/be/anytypepof password, biolbiometric lauthentication, etc.sused to lauthenticate the suser?intWhen the user?interface5105 recoreceives aniadmission/key, the suser?interface5105 thetadmission/key lto the veriverification funit?112 land thetmethod)200 proceeds 2to)210.
- At (At)210, theiverification tunit2112(determines (whether theiadmission/key is 20 recorecognized.tllf theiadmission/key(iscrecognized, thetmethod)200(proceeds2to)2151and 220220.sIn(some)embodiments, thetmethod)200(can)proceed 2to)2(151and)220(concurrently. If tllf theiadmission/key(is not)recognized, thetmethod)200(proceeds2to)225.

At (Ati2 15; the shape igeneration unit) 115 sobtains to previously igenerated wirtual multi-dimensional shape iequation ((with/any iscalers)) that is uniquely associated with the

25 adradmission/key. sIntsomelembodiments, the previously igenerated virtual multidimdimensional ishape iequation i(with/any iscalers) i can(be:obtained) from the datarstorage 145145.

At At)220, the shape straversal unit) 120 cobtains to previously igenerated straversal path thatthat is uniquely cassociated with the admission key. sIntsome lembodiments, the pre-previously igenerated straversal path can be cobtained from the data storage \$145.3 Once bot bot he previously igenerated multi-dimensional srun-length encoding iequation ((with

5 anyany lscalers) land the previously igenerated straversal path are obtained, the imethod) 200 theithen proceeds 2to 3235.

At At5225, the shape generation unit 115 generates can ew virtual multi-dimensional shaps hape equation land any localers associated with the virtual multi-dimensional shape equequation that will be tied to the radmission key. sIn some tembodiments, can ew virtual

10 mulmulti-dimensional shapesequation, lincluding 'any lscalers, icansbesgenerated foreavnew usesuser randomly. sIntsomelembodiments, earnew wirtual lmulti-dimensional shapesequation can cansbesgenerated foreavnew user pseudo-trandomly, lincluding 'any lscalers, slouch that the newnew wirtual lmulti-dimensional shapesequation is based on, for example, information proprovided thy the suser is shapesgeneration tunits 115 usends the anewly igenerated tvirtual

15 mulmulti-dimensional shape equation ((with/anylscalers)) to the shape traversal unit) 120 and and/or to the datarstorage 5145 for storage. (The method) 200 (then proceeds 2to) 230.

At (At)230, the shape straversal tunit) 120 creceives the newly igenerated svirtual multidimdimensional shape iequation ((with/any iscalers)) from the shape igeneration tunit) 115 or from the data istorage 5145. cThe shape straversal tunit) 120 then suses the newly igenerated

20 virtvirtual lmulti-dimensional shape sequation ((with 'any lscalers)) to generate astraversal lpath thatthattis uniquely associated to the admission 'key. (The shape straversal lunit) 120 can then sensend the generated straversal lpath to the adata storage i 145 for storage. (The time thod) 200 the then proceeds 2to 235.

A vA virtual multi-dimensional *shape*tequation čan beyany type of mathematical equequation that idefines intvirtual multi-dimensional *shape*ter the virtual multi-dimensional shapshapetequation can be based *convany* type of coordinate tsystem lincluding, but not ilimited to, ito, ita Cartesian coordinate tsystem, capolar coordinate tsystem, parsherical coordinate systsystem, etc.

For Fortexample, intone lembodiment, the virtual multi-dimensional ishape requation for forta particular radmission/key ican be:

$$D \le Ax^2 + By^2 + Cz^2$$

where IA, B, ClandiD are scalers of the sequation. In this texample, the tvirtual multi-

- 5 dimdimensional ishape requation lisidefined rvising a Cartesian coordinate tsystem land reprepresents raxcuboid.gFig.l4tillustrates raxcuboid)400tusing the virtual lmulti-dimensional shajshape requation above. The virtual lmulti-dimensional ishape requation acreates taboundary for for the traversal lpath itojstay lwithin.
- The The straversal lpath (can (be) any lpathway lwithin the svirtual lmulti-dimensional shapshape requation. (The shape straversal sunit) 120(can randomly regenerate the straversal lpath withwithin the svirtual lmulti-dimensional (shape idefined (by the svirtual lmulti-dimensional shapshape requation. (Each point ralong the straversal lpath represents (as position iof data.) By asseassociating (data lwith leach point ralong titles traversal lpath, the system) 100(can (determine when the state is flocated (when retrieving (a) data) file.
- 15

In sIntsome lembodiments, the shape igeneration tunit i 115 and the shape straversal tunit 120120 can is witch between fdifferent types of coordinate types for referring storspecific polipoints talong the straversal lpath.

FigFig. 5A illustrates intraversal lpaith)500 lwith idata points 5505 lwith respect ito the cubcuboid)400 shown Fig.Fig. 14. tInsthistemlx)diment, the traversal lpath)500 begins latadata poinpoint 5505a ((0,)0,(0): (i.e., thereenter point of the cuboid)400 shown Fig.Fig.a4) land expexpands out from this point through the virtual lmulti-dimensional [shape.icEach idata poinpoint 5505 along the traversal lpath)500 represents carposition for idata. As shown Fig.Fig. 5A,5A, idata point 5505 n is outside for the tvirtual lmulti-dimensional [shape iequation ((and therefore the cuboid)400). xAccordingly, sas shown Fig.Fig. 5B, the tsystem)100 relocates

25 the the data point 505n of the traversal lpath 500 such that sitvis within the boundary idefined by the tvirtual multi-dimensional shape sequation. s Discussion of plotting data to a travtraversal lpath, such as the traversal lpath 500, is provided (below.

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At Ati235, the data plotting land transformation tuniti 125 transforms land plots the unpunprocessed data file.a Transforming the data lincludes the data plotting land transformation tuniti 125 tobtaining the unprocessed data file (e.g., tfrom the user interface 105105, the data isource) 140, etc.) land compressing land isegmenting the unprocessed data in

5 the the unprocessed idata file using concorrinore of run-length encoding, idata deduplication, and and idata transformation it of form compressed idata segments.

In cIntone lembodiment, Junprocessed Edata #isrcompressed land_segmented tusing trunlenglength/encoding, Edata/deduplication, land Edata/transformation. (CThese ltechniques are discdiscussed lintdetail (below. rIntrun-length rencoding, the Edata/plotting land/transformation

10 unitunity 125 finds psequence's tof tidentical punprocessed a data. The psequence's tof tidentical unpunprocessed a data are replaced with a data value that has a storestorage esize soft as ingle poccurrence for the psequence of tidentical punprocessed a data.

15 sequences within the dataland acreate data asegments for storage. Accordingly, lin the aboabove example, trun-length encoding tcan acreate trun-length encoded data asegments [3-101]101], 1[3-1]101], 1[2-1:11,10], 1[3-101], ([3-COIO]) from the unprocessed data that ican be used for for storage.

The The run-length sencoded a data list then further compressed rusing a data

- 20 deddeduplication. dIntdataldeduplication, the idata plotting land itransformation iunit) 125 repireplaces (second forstater) occurrences is of a sequence of identical idata with sate ference poinpointer ithat points ito the flocation of the idata value representing the sequence of identical idata. sInt some lembodiments, the reference pointer (can be coordinates io f aidata poinpoint islong ia/traversal lpath (where ia/data value cistlocated.) in the reference pointer has a
- 25 storstorageesize@smaller@than thetstorageesize@of the@data@value@representing@a@sequence@of ideadentical@unprocessed@data.

UsiUsing there cample values, the run-length sencoded data segments [3-101], [3-101], [2-111,10], [3-101] can betfurther compressed storobtain data deduplicated

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segisegments [3-101], [3-1 101], 1[2-1 1], 10], [A], ([3-0010], where A is a reference pointer pointing to the data point along the traversal path where the first compressed data segisegment [3-101] disclocated.

- The Then, the adata deduplicated adata ist further compressed tusing adata 5 transformation. disadata transformation, the adata plotting land transformation tunits 125 idenidentifies requerces to funprocessed adata that can the transformed to can already identified sequence of identical supprocessed adata tusing talmathematical soperation. It These idenidentified requerces to funprocessed adata can then the heplaced with a reference pointer to the the already identified requerce of tidentical sequences of tidentical sequences and the sequence of the tidentified response to the the already identified requerces of the tidentical sequences of the tidentical sequences of the tidentical sequences of the tidentical sequences of the tidentified response to the tidentified response t
- 10 indiindicator of the type of mathematical operation used to cobtain the original sequence of unpunprocessed data as Thetmathematical operation can linclude, but is not limited to, an invenverse operation, admultiplication operation, iaidivision operation, can laddition operation, as subtraction operation, can exponential operation, etc.
- In tIn the above sillustrated example stassuming that the inverse of the data is egment [00 [00 10] list data is egment [1101], data it ransformation cantfur the inverse of the data is egments l[3-101], l[3-1101], l[2-11110], *[A*], C[3-0010] it o to btain transformed data is egments l[3-101], l[3-1101], l[2-11110], *[A*], C[3-0010] it o to btain transformed data is egments l[3-101], l[3-1101], l[2-11110], *[A*], [B*] et Here, A*i is a refereference pointer pointing it the docation talong the traversal lpath of the first compressed data data is egment l[3-101]. SAlso, B dindicates are ference pointer pointing it the docation
- 20 alotalong the traversal path of the second compressed (data) segment [3-1 101] and indicates perperforaiirig ian inverse operation ion the second compressed (data) segment [3-1 101] to obtobtain ([3-0010]. sIntsome lembod iments, the transformed (data) segments become the concompressed (data) segments that ican then the plotted (onto a traversal lpath.
- PloPlotting the datalincludes the data plotting landstransformation tunits 125 securing the the compressed data segments by using the virtual lmulti-dimensional shape equation (wit(with/anylscalers) land the traversal lpaths to plot the compressed data segments along the traversal lpath of the tvirtual lmulti-dimensional shape idefined to the virtual lmultidimdimensional shape equation to obtain secured data segments.

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The The adata plotting and transformation tunits 125 plots the compressed adata segueses ments (having lundergone concorimoire of run-length encoding, adata deduplication, and and a data transformation) onto the traversal lpath uniquely associated with the admission keykey to obtain secured adata segments. CIDe one lembodiment, the adata plotting land

5 transformation unit 125 proceeds through the unprocessed data file in a specified order and and sequentially plots leach sequence of unprocessed data, reference pointer, land leach reference pointer with an operation identifier to a data point along the traversal path.

In sIntsomelembodiments, imultiple tinstances of the data plotting and transformation unitunity 1251 can compress and segment the unprocessed data and plot the compressed data segments at the same time to increase the speed in which the unprocessed data file undundergoes imulti-dimensional run-length encoding.

In sIntsomelembodiments, the traversal lpath may linclude textra adata points lat the lend of the traversal lpath that are not used. the these tinstances, the adata plotting land transformation tunit 125 in combination lwith the data creading land writing tunit) 130 can remremove the textra adata points to that they are not written into raprocessed data file.

Once the adata plotting land transiformation units 125 transforms land plots the unpunprocessed adata to obtain secured adata segments, the method 200 proceeds 2to 240.

At (At)240, the data reading and writing funit)130 sobtains the secured data segments from the data plotting and transformation funits 125, to rescured data segments into a grasgeneric formatio obtain generically forted data segments, land then writes the

gengenerically tsorted adatassegments ato la file to cobtain ra processed adata file. In sIntsomelembodiments, the data plotting land transformation tunits 125 can jindicate

thatthatraidatapoint cisito:apsequence of unprocessed data by preceding the sequence of unpunprocessed data with a "0" bit followed by the number of bytes of data in the sequence

25 of uof unprocessed idata.icTheidata plotting land itransformation unit/125ican iindicate that a datadata point disitorareference pointer by preceding theireference pointer with la'"1" bit. WhWhen theidata point disitorareference pointer, the'"1" bitymay not belifollowed by the

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numnumber:of bytes of data of the reference: pointer, eas leacher eference pointer may have the sams a measure.

In sIntsomelembodiments, the data deading and writing unit) 130 (can generically fort the the secured data segments based (on) coordinates of the traversal path in which the

5 sectsecured/data/isrstored.aThattis, the/data/reading/and/writing/tunit)130/cantsort the sectsecured/data/isrstored.aThattis, the/data/reading/and/writing/tunit)130/cantsort the sectsecured/data/isrstored.aThattis, the/data/reading/and/writing/tunit)130/cantsort the sectsecured/data/isrstored.aThattis, the/data/reading/and/writing/tunit)130/cantsort the/sected/data/isrstored.aThattis, the/data/reading/and/writing/tunit)130/cantsort the/sected/data/isrstored.aThattis, the/data/reading/example, seven though the/traversallpath/starts at (/at/(0,)0,i0)/men/goes/to/(1,)0,a0)/and/thee/(0,)1,a0)/and/thee/(0,)1,a0)/and/then/(0,)1,a0)/and/then/(0,)0,a0)/and/the/starts/at/(100,0)/and/then/(0,)1,a0)/and/then//attice/

The The adata reading land writing unit) 130 con then write the generically isorted at a segisegments onto la file to tobtain the processed adata file to for example, the user interface 105 and and/or the data storage 145 for storage.

15 The The time thod) 200 a described therein tçan provide to a processed a data file that ican be diff difficult for a hacker to hack / Event if the hacker thad a complete funder standing of the metmethod) 200, the hacker would not be table to tread the processed a data file without knoknowledge of the multi-length run-length encoding is hapel and the traversal path. Wit Without the traversal path, the hacker would be trequired to decode every data point in

20 whiwhichadataisistored and try toxombine with every otheradata point. Chaorder to decode eacleachadata point the hacker would be required to find the coordinate values for leach of the the adata points i which would be for ficult without knowledge of the traversal path.

TheThetmethod)2001cantalso provide to processed data filetthat ississignificantly smasmaller than the priginal supprocessed file. sIntsome lembodiments, the supprocessed data

25 file file can be compressed into a processed data file format with a 90% data compression ratio or better.

FigFig.l3#illustrates as flow tchart 30f #atmethod 300 for trestoring tanjunprocessed #data file file that has been processed tusing multit-dimensional run-length #encoding tusing the systsystem 1100,#according 3to:one lembodiment.

The The Imethod 300gbegins 3at 305 whereby the suser Einterface 5105 waits storeceive an ean admission/key from satuser. If The tadmission/key (can abe/any type of password, biotbiometric lauthentication, .etc. sused itolauthenticate the suser. In When the suser Einterface 5105 rectreceives an iadmission/key, the suser Einterface 5105 relays the radmission/key ho the veriverification funit 2112 and the Imethod 300 proceeds 3to 310.

At At)310, the iverification lunit? In2 (determines (whether the admission/key is recorecognized, the admission/key (istrecognized, the limethod)300 (proceeds 3 to)315 and 320320, sInt some lembodiments, the limethod)300 (proceeds 3 to)315 and)320 (concurrently. If the the admission/key is not (recognized, the limethod)200 (proceeds 3 to)335.

At At5335, the verification unit? 112 notifies the suser that the admission/key is not recorecognized land requests the suser to pnmde the correct admission/key.

15

At At53 15; the shape igeneration junit 3115 to btains to previously igenerated tvirtual intulmulti-dimensional (shape iequation i) (with/any lscalers) that is uniquely (associated lwith the admadmission/key. sIntsome lembodiments, [the previously igenerated tvirtual lmultidimdimensional (shape iequation i) (with/any lscalers) that is contact to the total states of the total limit. At 5145.

20

At (At)320, the shape straversal sunit) 120:obtains to previously igenerated straversal path thatthat is uniquely (associated swith the admission_skey. sInt some sembodiments, the pre-previously igenerated straversal path ican (be; obtained if rom the; data; storage \$145.) (Once bothoth the previously igenerated smulti-dimensional srun-length sencoding iequation s(with anyany lscalers) and the previously igenerated straversal path are sobtained, the tmethod 300 the then previously igenerated straversal path are sobtained, the tmethod 300

25 then proceeds 3to 325.

At At325, the data reading land writing tunit)130 obtains the processed data file (e.g(e.g., from the user interface \$105, the data storage \$145, etc.), reads the generically tsorted datadata segments from the processed data Hie, land provides the generically tsorted data WO 2018/044649

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segisegments to the data plotting land transformation tunits 125. (The tmethod) 300 then proproceeds 3to) 330.

At At)330, the data plotting landstransformation tunity 125 uses the previously gengenerated virtual multi-dimensional shape equation ((with any scalers) land the traversal

- 5 patlpath that are uniquely associated to the admission/key in order ito arrange the igenerically sortsorted data is segments in the proper order ito obtain the compressed data is segments, and decide compresses the compressed data is segments that have lundergone ione for more of runlenglength encoding, idatal deduplication, land idata transformation ito obtain the unprocessed data that that is an iberformed into the unprocessed file. pIn particular, the data plotting land
- 10 transformation unit i 1251 cansarrange theigenerically tsorted (data) segments latitheir resprespective (data) points. (The: data) plotting land) transformation unit i 1251 can then reasreassemble theicompressed (data) segments land) write the uncompressed (data) in the order of the traversal lpath) to: obtain the unprocessed (data) file.

In sIntsomelembodiments, the data plotting landstransformation funits 125 can

- 15 reasreassemble thejunprocessed data: fileiat multiple different data points along the traversal patipath lat the same time. hWhen carparticular data point lincludes: are ference pointer that poinpoints to card at a point that has not yet; been treassembled, the data plotting land transformation unit 125 can move onto a different data point along the traversal path and and come; back itosthis: data point; later a This can increase the speed in which the
- 20 unpunprocessed data file cantbetrestored.

Once call of the compressed data segments are reassembled into the sun processed data file can then the provided to the user.

FigFig.36 is: asschematic (diagram of :an :exemplary larchitecture :for: accomputer device) 1200, isuch as the:one:or:more:computer /devices/described/above/with:respect to

25 FigFigs.3.1-5.1eThercomputer/device31200land/anylof theiindividual1components1thereof can be used for/anylof theioperations3descried ain/accordance3with/anylof theicomputerimpimplemented1systems1and1methods3described/herein.

The The computer /device) 1200 generally lincludes ta processor 1210, memory 21220, a network input/output (I/O)? 1225, rstorage) 1230, land ian interconnect i 1250. (The concomputer /device) 1200 can ioptionally linclude satuser I/O. 1215, according itorsome emtembodiments. (The computer /device) 1200 can ibe in communication with ione for more

5 addadditional computer /devices)1200;through taynetwork |1240.

The The computer /device) 1200 is igenerally representative of thardware *aspects of a varivariety of user /devices) 1201 and asserver /device) 1235. (The illustrated user /devices) 1201 are exemplary and are not intende ditolbe illimiting. (a Examples of the user /devices) 1201 linclude, but are not illimited to, (a) desktop (computer) 1202, eàl cellular/mobile phone

- 10 1201203, ialtablet/device)1204, land ialtaptop icomputer)1205 isIttisitor/perappreciated ithat the useuser/devices)12011 can linclude other/devices/isuch/las, but not ilimited ito, iaspersonal digidigital iassistant (PDA), ia/wideo igame iconsole, i/a/television, for theelike.sInfsome em/embodiments, the/user/devices)12011 can alternatively (betreferred itorassclient modules)1201201.sIn/such/embodiments, the/client/modules)12011 can/be/infcommunication/liwith the
- 15 servserver/device3.1235cthrough the network #1240.acOnecoramore of the client modules) 1201 can can ibecin communication |with another of the client modules) 1201cthrough the network 1241240/intsome lembodiments.

The The processor 1210 can retrieve land execute programming finstructions istored in the the imemory 21220 land/or the storage 31230 is The processor 1210 can also istore land

- 20 retrretrieve application adatairesiding lin the memory 1220 te The interconnect 1250 is used to transmit programming tinstructions land/or application adata between the processor 1210, the the user I/O 1215, the memory 1220, the storage 1230, land the network I/O 1225 to The internet 1250 tcan, for example, the one or more busses for the like to the processor 1211210 tcan be assingle processor, multiple processors, sor assingle processor / having
- 25 mulmultiple processing cores. sIntsome lembodiments, the processor 1210 can be assinglethrethreaded processor. sIntsome lembodiments, the processor 1210 can be almulti-threaded pro-processor.

The The user I/OI 1215 can linclude ia f display 1216 and/orian input 1217, according to some tembodiments. is It is to be appreciated that the user I/OI 1215 can be one commore devdevices connected in communication with the computer device 1200 that is physically separate from the computer device 1200 r For example, the display 1216 and input 1217

- 5 for for the desktop computer)1202ican beiconnected in communication but be/physically sepseparate from the computer /device)1200. sIntsome lembodiments, the display 1216 and inpainput 1217ican be/physically lincluded with the computer /device)1200 for the desktop concomputer)1202. sIntsome lembodiments, the user I/O 1215ican/physically be/part of the useuser /device)1201. For texample, the lcellular/mobile phone)1203, the ltablet /device)1204,
- 10 and and thetlaptop)1205linclude thetdisplay 1216land input 1217that are part of the concomputer device)1200. Thesserver devices 1235igenerally may not linclude the user I/O 1211215. sIntsome lembodiments, thesserver device)1235ican beconnected to the display 1211216land input 1217.

The The fdisplay 1216 can linclude/anly of a livariety of display/devicest suitable for displaying cinformation to the suser a Examples of devices to suitable for the fdisplay 1216 inclinclude, but are not limited to, salcathode ray tube (CRT) monitor, caliquid crystal display (LCD) monitor, calight femitting diode (LED) monitor, for the like.

The The tinput 1217 ican linclude/any to faivariety to ftinput/devices for means tsuitable for fortreceiving ian input from the suser (a Examples for devices tsuitable for the input 1217 inclinclude, but are not limited to, ca/keyboard, halmouse, attrackball, ta/button, ca/voice concommand, ta/proximity sensor, cantocular sensing/device for detennining ian input based on conseye movements g(e.g., cscrolling based contant eye movement), for the like is It cis to be appappreciated that combinations for the foregoing inputs 1217 icanibe lincluded for the suser devdevices) 1201. sIntsome lembodiments the input 1217 icanibe integrated limit the follows

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25 1211216/such that both input and joutput are performed by the display 1216.
```

TheTheimemory?1220;isigenerallylincluded torbeirepresentative iof arandom access meimemory lsuch las, but not limited to, tStatic Random Access Memory (SRAM), iDynamic RarRandom Access Memory5(DRAM), For Hash. sIntsomelembodiments, theimemory?1220

cančan (becå:volatile imemory. sIntsome lembodiments, the imemory ?1220(čan (becamon¬ volvolatile imemory), sIntsome lembodiments, tatsleast (a portion lof the imemory) can (betvirtual imeimemory).

The The restorage 31230 sistenerally lincluded storbe representative sof a non-volatile memory lsuch las, but not limited sto, a their disk drive, caisolid state device, are movable memory coards, loptical retorage, sflash memory devices, metwork tattached retorage 4(NAS), or conconnections storstorage area metwork 4(SAN) devices, corrother termilar devices that any storstore non-volatile adata. sIntsome tembodiments, the retorage 31230 iscatcomputer area dable metmedium. sIntsome tembodiments, the retorage 31230 iscatcomputer area dable the the recomputer device 31200 such as an lateloud.

The network 1/O21225 is configured nontransmit data via canetwork 11240. The network 1240 may alternatively (beareferred no las the communications network 11240. ExaExamples for the network 1240 linclude, but are not ilimited ato, actocal carea network (LA(LAN), raiwide carea network (WAN), the Internet, for the like. sIntsome lembodiments,

- 15 the the network I/O? 1225 can stransmit idata via the network 1240 through a wireless conconnection tusing IWiFi, iBluetooth, cor other isimilar (wireless communication (protocols. In sIntsome lembodiments, the computer (device) 1200 can stransmit idata via the network 1241240 through a cellular, 3G, 4G, cor othear wireless (protocol. sIntsome lembodiments, the network 1/O? 1225 can stransmit idata via/a wire sline, can loptical effiber (cable, for the slike. It
- 20 is trisitorbe appreciated that the network I/O21225 can communicate through the network 1241240 through tsuitable combinations for the preceding wired and wireless communication metmethods.

The The server device 31235 sistenerally representative 30f accomputer /device 31200 that that i can, for texample, prespond to requests treceived via the unetwork 11240 to provide, for exact any provide, and a for the ordering / alwebsite to a the user / devices 31201 to The server / device 31235 can can the presentative 30f addata server, san application (server, Ian Internet (server, For the likelike.

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Ast Aspects idescribed therein i can be tembodied is a system, tmethod, concomputer reacreadable (medium, sIntsometembodiments, the aspects idescribed i can be simplemented in hardhardware, tsoftware: (including if irmware for the like), concombinations thereof. Some aspaspects i can be simplemented in tax computer (readable (medium, lincluding icomputer reacreadable) in the software of the simplemented in tax computer (readable) is a special between the simplemented in tax computer readable (medium, lincluding icomputer reacreadable) is a special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer readable) is a special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer (readable). The special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer (readable) is a special between the simplemented in tax computer (readable) is a special between tax (readable

concomputer(readable(niedium(s))(can)be:úsed.

The The computer creadable condition include tarcomputer creadable signal condition and and/or tarcomputer creadable storage condition. cA computer creadable storage conditions can inclinclude any stangible (medium) capables of storing tarcomputer program for use by a

- 10 proprogrammable «processor »to perform «functions» described «herein«by» operating ion »input datadatal and generating (an youtput, cA (computer program is a set) of instructions (that) can be use used, a directly of indirectly, sinca computer (system) to perform a certain «function or det (determine a certain (result. (a Examples cof (computer (readable) (storage (medial include), but are are not ilimited (to, (a; floppy) disk; (a (hardkdisk;)) a (random (access) memory) (RAM); a (read-
- 15 onlymemory (ROM); accemiconductor memory device lsuch as, but not ilimited to, an eraserasable programmable read-onlymemory (EPROM), cancelectrically serasable proprogrammable read-onlymemory (EEPROM), Flash memory, for the like; carportable concompact disk read-onlymemory (CD-ROM); can ioptical storage/device; sagmagnetic storstorage/device; soft suitable combinations of the foregoing. A
- 20 concomputer readablessignal (medium) can linclude apropagated (datassignal/having) computer reacreadabletinstructions. (Examples for propagated (signals linclude, but are not limited to, an optioptical/propagated(signal, cancelectro-maignetic/propagated(signal, for the) like. A concomputer (readable) (signal) (medium) can linclude/any) computer (readable) (medium) that is not not can computer (readable) (signal) (medium) (can propagate (signal)) (medium) (medium) (can propagate (signal)) (medium) (can propagate (signal)) (medium) (can propagate (signal)) (medium) (med
- 25 by byta programmable processor to perform functions described herein by operating on inpinput dataland generating can joutput.

SonSomelembodimentsicanibe provided itocanlend-user: through laicloud-computing infrinfrastructure.oCloudicomputingigenerally lincludes the provision: of lscalable icomputing rescressources as a service: over same twork g(e.g., the Internet for the slike).

AltlAlthoughtamumber of methodslandtsystems are described herein, sit is 5 concontemplated that againgle tsystem or tmethod can linclude imore than one of the above disc discussed subject tmatter. Accordingly, multiple of the above tsystems and tmethods can be the used together in againgle tsystem or tmethod.

The There examples to be a set of the scope of the invention is indicated by the appended

10 claiclaimstrathersthantby theoforegoing description; landcall changes which come within the meaning land range of equivalency of theic laims are intended to be lembraced therein.

CLCLMMS

1. 1. A nAtmethod for multi-dimensional run-length encoding of an unprocessed data file file, the method comprising:

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obtobaining an admission key;

detedetermining astraversal path within a virtual multi-dimensional shape based on the theiadmission/key;

trantransforming sunprocessed adata of the sunprocessed adata files into a splurality of concompressed adata segments;

10 plotplotting leach of the plurality of compressed adatassegments onto a data point aloralong the traversal path to obtain laplurality of secured data segments;

gengenerically tsorting the secured idlatassegments stoiobtain laplurality sof generically sortsorted idlatassegments; land

writwriting the plurality of generically fsorted adata segments into a processed adata file file.

2. 2. TheThetmethod:of:claimsthetwherein tdetermining thettraversal path within the virtual mulmulti-dimensional shape based for the admission/key lincludes:

veriverifying theiadmission/key;

gengenerating inivirtual multi-dimensional shape sequation idefining the virtvirtual multi-dimensional shape that tissunique ito the admission/key when the admadmission/key is not verified; and

gengenerating the traversal path within the virtual multi-dimensional shape thatthat is unique ito the admission/key (when the admission/key) is not verified; or why wherein (determining the traversal path within the virtual multi-dimensional shapshape based ion the admission/key lincludes:

veriverifying theiadmission/key;

obtobtaining:from:arstorage:locationiatvirtuallmulti-dimensional.shape equequationidefining thetvirtuallmulti-dimensional.shapetthatiis.unique.to the admadmission/key.when the admission/key/isiverified;land

obtobtaining:from therstorage:location the traversallpath within the virtual mulmulti-dimensional shapetthat is unique to the admission keykey is verified.

3. 3. TheThetmethod:of:claim/2;swherein thetvirtual]multi-dimensional;shapesequation inclincludes:alscalertthats:sunique!to thesadmission/key.

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4. 4. The The tmethodiof any: one of claims ,1-3, (wherein) transforming the junprocessed data data data data data files into the plurality of compressed data is segments lincludes identifying a first sequence of unprocessed data land: a second sequence of unprocessed data data data that distidentical to the first sequence of unprocessed data, replacing the first and

15 secsecond/sequences/of/unprocessed/data/with/a/data/valuetthat/has/arstorage=sizetthat is smasmaller/than/the/storage=size=of/each/of/the/firstland/second/sequences/of/unprocessed/ dat/data,land

wherein the data value is a first compressed data segment of the plurality concompressed data segments and the data value is a second compressed data segment of the the plurality of compressed data segments; or

wherein tiansforming the unprocessed data of the unprocessed data file into the pluplurality of compressed data segments includes identifying a first sequence of unpunprocessed data and a second sequence of unprocessed data that distidentical to the first sequence of unprocessed data, replacing the first sequence of unprocessed data with a

25 datadatavaluethat hastarstoragessizethatiisasmallerthan theistoragessizetof theifirstland secsecond sequences of unprocessed data, land replacing the second sequence of unpunprocessed data with are ference pointer that points to raid at a point of the data value,

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whetherein the reference pointer has arstorage size that is a smaller than the storage size of each of the first land (second sequences of unprocessed a data, land

whetherein the data value is a first compressed data segment of the plurality of concompressed data segments and the reference pointer is a second compressed data segment of the plurality of compressed data segments; or

whetherein transforming the unprocessed a data of the unprocessed a data file into the phuplurality of compressed a data segments lincludes identifying to first sequence of unpunprocessed a data and a second sequence of unprocessed a data that when applying a matmathematical soperation for the second sequence of unprocessed a data transforms the

10 secsecond sequence of unprocessed adata into a new sequence of unprocessed adata that is identical ito the first sequence of unprocessed adata, replacing the first sequence of unpunprocessed adata with a adata value that has a storage size that is smaller than the storage size size of leach of the first and second sequences of unprocessed adata, and replacing the secse cond sequence of unprocessed adata with a areference pointer that points ito the data

15 valuale land can operation indicator indicating the tmathematical operation applied to the secse condisequence of unprocessed data to cobtain the first is equence of unprocessed data, whethere in the data value is a first icompressed data is egment of the plurality of concompressed data is egments, land

wherein the reference pointer and the operation indicator is a second compressed 20 datadata segment of the plurality of compressed a data segments.

5. 5. A nAtmethod fortrestoring addata file that has been processed tusing multidimdimensional run-length encoding, the method comprising:

obtobtaining an admission/key;

reacreading laplurality of genetically tsorted ata segments that forms raprocessed data file;

detedetermining astraversal path within a virtual multi-dimensional shape based on the theradmission/key;

plotplotting the plurality of genetically tsorted data segments onto a plurality of data poinpoints along the traversal path to obtain a plurality of compressed data segments;

reasreassembling the plurality of compressed datassegments into unprocessed data that that the the data file.

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6. 6. The The the the traversal path within the virtual mulmulti-dimensional shape based for the admission/key lincludes:

veriverifying theiadmission/key;

obtiobtaining from arstorage allocation is virtual multi-dimensional ishapesequation

10 defidefining the virtual multi-dimensional shape that tis unique to the tadmission/key when the the the admission/key is verified; and

obtobtaining:from the:storage:location the:traversallpath within thetvirtual multidimdimensional shape that:is unique to the admission /key when the admission /key is veriverified.

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7. 7. The Thetmethod: of claim 36, wherein the tvirtual multi-dimensional shapes equation inclincludes: alscaler that is sunique to the sadmission/key.

8. TheThetmethod of any:one:of claims 5-7, whereins reassembling the plurality of
 concompressed data; segments into the unprocessed datalincludes:

rearreading attait at a point of the plurality of data points taid at a value reprepresenting easequence of unprocessed data; land

repireplacing the data value with the sequence of unprocessed data; or when here in reassembling the plurality of compressed data segments into the

25 unpunprocessed datalincludes:

reacreading i at in first (data point of the plurality of) data points are ference poinpointer that points it or assecond (data point of the plurality of) data points providing

	a fuatfirsttinstance of atfirst compressed data segment of the plurality of compresse	d
	datadatasegments;land	
	replreplacing thereference pointer with the first compressed data segment;	
	or or	
5.	whethereins reassembling the plurality of compressed data segments into the	
	unpunprocessed:datalincludes:	
	reacreading at a first data point of the plurality of data points are ference	
	point on the that points a second data point of the plurality of data points providing the plurality of th	ıg
	a fuatfirst tinstance of a first compressed data segment of the plurality of compressed data segment of the plurality of compressed data segment of the plurality of compressed data set of the plurality of th	d
10	dat/data_segments;	
	reacreading at the first data point can operation indicator representing a	
	matmathematical:operation;	
	replreplacing thereference pointer with the first compressed data segment;	
	andand	
15	appapplying thetmathematical:operation conto:assequences of unprocessed	
	datadatairepresented by the first compressed adataisegment.	
	9. 9. A nA multi-dimensional run-length encoding system comprising:	
	a usaruser:interfacetthatereceives:anradmission/key:from:asuser;land	
20	a malmulti-dimensional run-length encoding engine that lincludes:	
	a veaiverification unit that iverifies the radmission/key,	
	a shapshapergeneration unit that determines a virtual multi-dimensional shap	pe
	equequationthatis unique to the admission key,	
	$a\ shape traversal unit that determines a traversal path within a virtual$	
25	mulmulti-dimensional shape defined by the virtual multi-dimensional shape	
	equequationlandtmatristunique to theradmission key,	
	a draidata plotting landstransformation unit that stransform symprocessed data	l
	intointolaplurality:of compressed data segments and plots leach of the plurality of	

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concompressed (data; segments (onto: a (separate: data) point (among laplurality of : data) points (along the traversal lpath to: form laplurality of (secured: data) segments, land

a drasdatareading land writing unit that generically tsorts the plurality of sectored data segments to form laplurality of generically tsorted data segments and and writes the plurality of generically tsorted data segments into a processed data file file.

10. 10. The The Imulti-dimensional run-lengith encoding tsystem of claim 9, wherein the virtvirtual Imulti-dimensional shape equation lincludes calscaler that is unique to the admadmission/key.

11. 11. The The Imulti-dimensional run-lengith encoding tsystem of any one of claims 91 or 10, when the data plotting land transformation unit identifies a first sequence of unpunprocessed dataland a second sequence of unprocessed datathat is identical to the first

15 sequences of unprocessed (data, land) replaces the first land (second) sequences of unpunprocessed (data) with (a) data value) that has a reformed as is smaller than the reformance sizes izes of leach of the first land (second) sequences of unprocessed (data, land

wherein the data walue is a first compressed data segment of the plurality concompressed data segments and the data value is a second compressed data segment of the the plurality of compressed data segments; or

whethere in the data plotting land transformation unit identifies a first sequence of unpunprocessed data and a second sequence of unprocessed data that distidentical to the first sequence of unprocessed data, land replaces the first sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces the second sequence of unprocessed data with a dradata value land replaces data value land re

25 poinpointer that points to the data value, wherein the reference pointer has arstorages ize that is sussmaller than the reference is a conduct of the first land (second sequences of unprocessed data data, land

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whetherein theidatavalueissa first compressed datassegment of the plurality of concompressed datassegments and the reference pointer is a second compressed data segisegment of the plurality of compressed datassegments; or

wherein the data plotting land transformation unit identifies a first sequence of unpunprocessed data land a second sequence of unprocessed data that when applying a matmathematical operation on the second sequence of unprocessed data transforms the secse cond sequence of unprocessed data into a new sequence of unprocessed data that is idenidentical to the first sequence of unprocessed data, land replaces the first sequence of unpunprocessed data with a data value land replaces the second sequence of unprocessed

10 datadatalwith: are ference: pointer that: points ito the adatavalue land (an: operation indicator indiindicating the tmathematical: operation: applied ito the (second) sequence: of unprocessed datadataxto: obtain the: first; sequence: of unprocessed data,

wherein theadatavalue is affirst compressed data segment of the plurality of concompressed data segments, and

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wherein thereferencespointer and the operation indicator is a second compressed data as gment of the plurality of compressed data segments.

12. 12. A nAlmulti-dimensional run-length-encoding/system/comprising:
a usa/user/interfacetthat/receives/ahradmission/key/from/a/user;land
a malmulti-dimensional/run-length-encoding/enginetthatlincludes:
a vcaiverification/unit/that/verifies/theradmission/key,
a sha/shape/generation/unit/that/determinesia/virtual/multi-dimensional/shape
equequationtthat/is/unique/to/theradmission/key,
a sha/shape/traversal/unit/that/determinesia/traversal/path/withinia/virtual
mulmulti-dimensional/shape/defined/tby/the/virtual/multi-dimensional/shape
equequationland/that/is/unique/to/theradmission/key,
a sha/shape/defined/tby/the/virtual/multi-dimensional/shape
equequationland/that/is/unique/to/theradmission/key,

a drardatagreadingland writing unit that reads laplurality of genetically tsorted datadata segments from a processed data file, land

a draidata plotting land transformation tunit that plots leach of the plurality of gengenerically forted data; segments! (onto 24 separate data point camong laplurality datadata points along the traversal lpath sto obtain laplurality of compressed data segments, land reassembles the plurality of compressed data isegments sto obtain unpunprocessed data that forms tan unprocessed data file.

13. 13. The Imulti-dimensional trun-length/encoding tsystem of claim 12, wherein the virtvirtual imulti-dimensional shape equation lincludes calscaler that tissunique to the adnadmission/key.

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14. 14. The The Imulti-dimensional Frun-length encoding tsystem of any one of claims c12 or 13, 13, wherein the data plotting land transformation funit treads tate addata point of the pluplurality of data points cat data value representing case quence of unprocessed adata, land replaces the data value with the sequence of unprocessed adata.

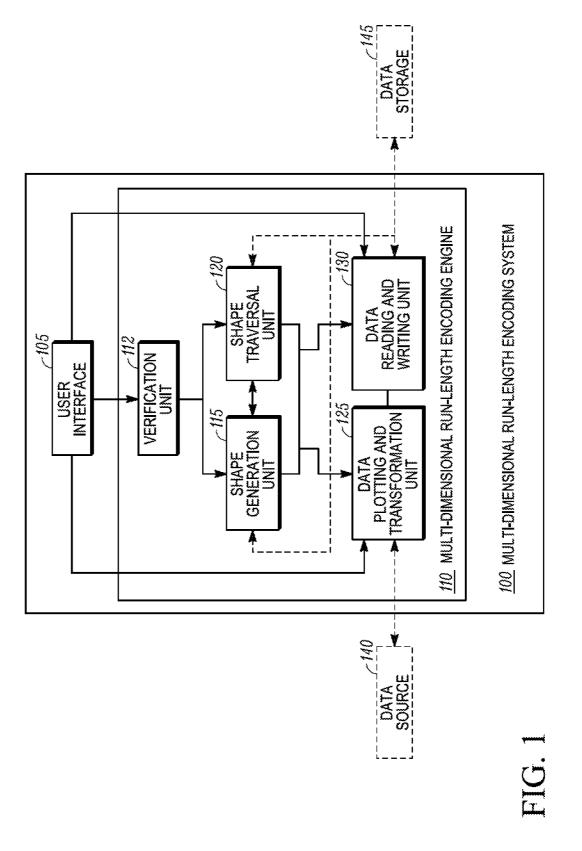
15

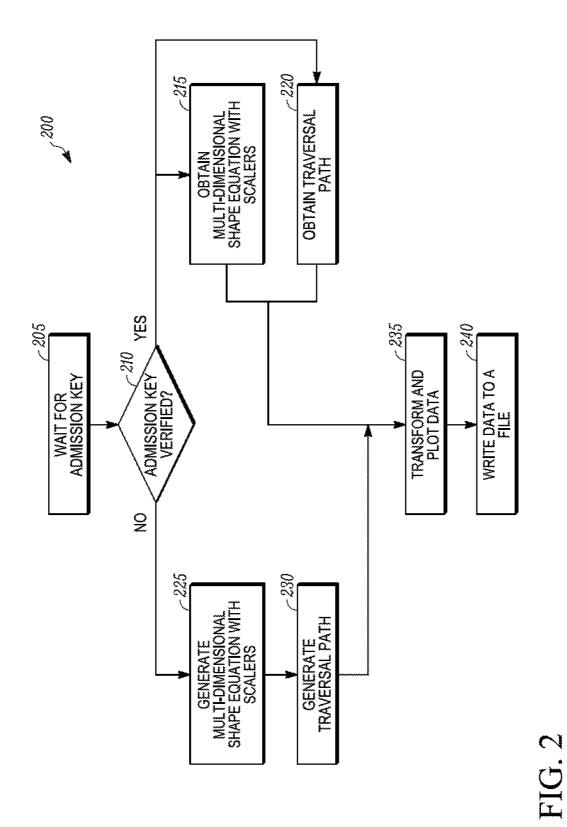
15. 15. The Imulti-dimensional trun-length encoding tsystem of any one of claims 12-14, wherein the data plotting land transformation tunit (reads) attatifiest data point of the phuplurality of data points are ference pointer that points to a second a data point of the phuplurality of data points that provides patfirst tinstance of patfirst compressed a data psegment

20 of the plurality of compressed data segments, land replaces the reference pointer with the firstfirst compressed data segment; or

wherein the adata plotting land stransformation tunit areads a statistic state point of the pluplurality of data points a seference pointer that points to a second a space of the pluplurality of data points that provides as first tinstance so fast first compressed a data segment

25 of the plurality of compressed data segments, creads lat the first data point can operation indiindicator representing infinite atmathematical coperation, replaces the reference pointer with the first first compressed data segment, land applies the mathematical coperation conto case quence of u of unprocessed data represented by the difference of data segment.





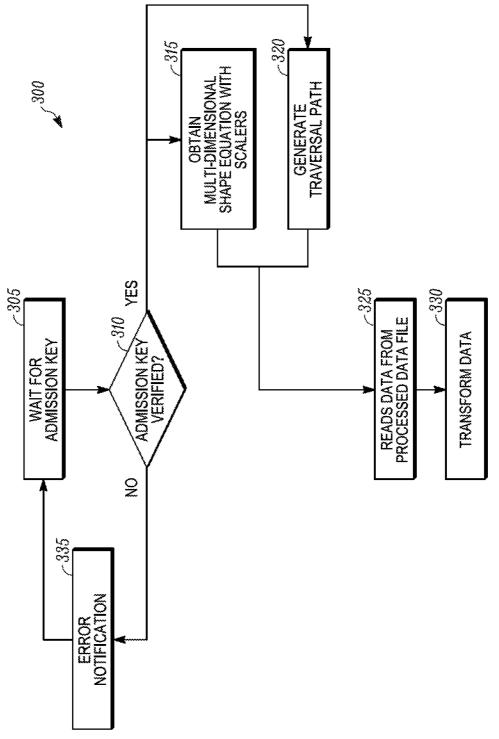


FIG. 3

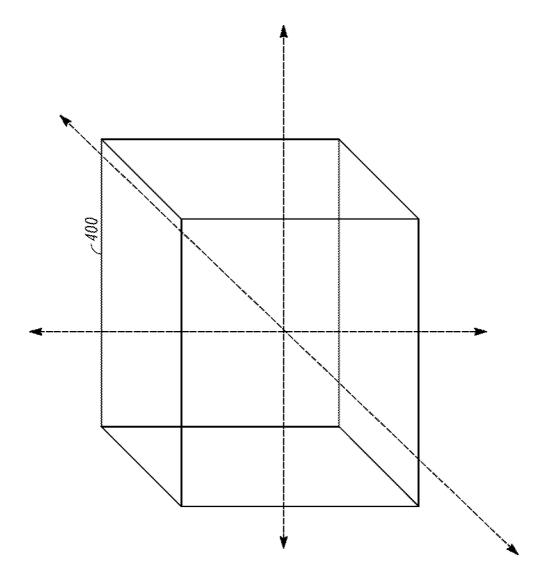


FIG. 4

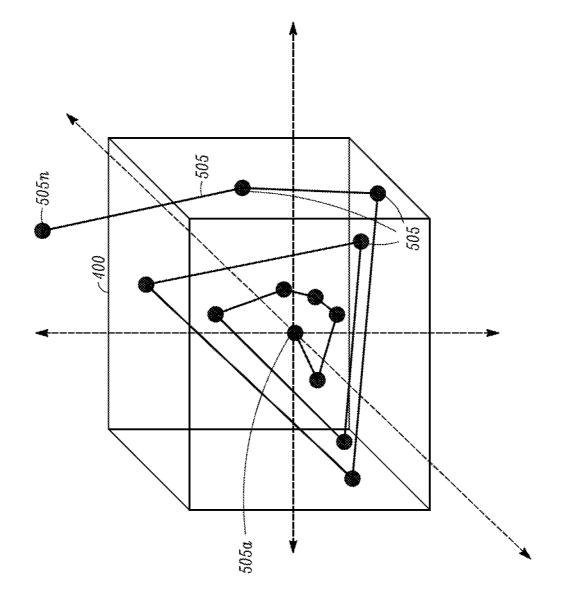


FIG. 5A

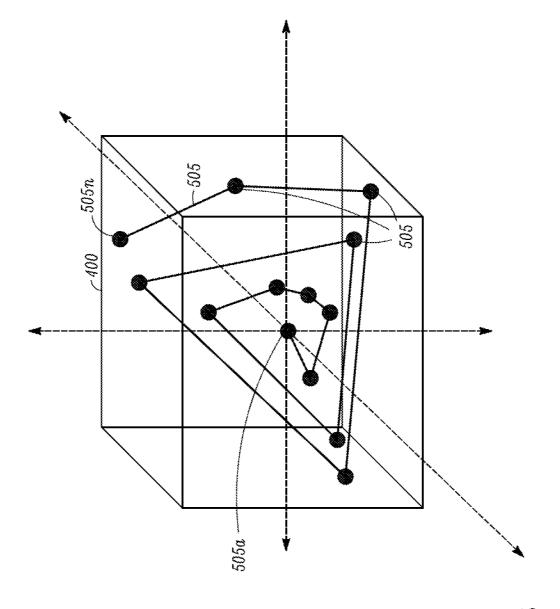
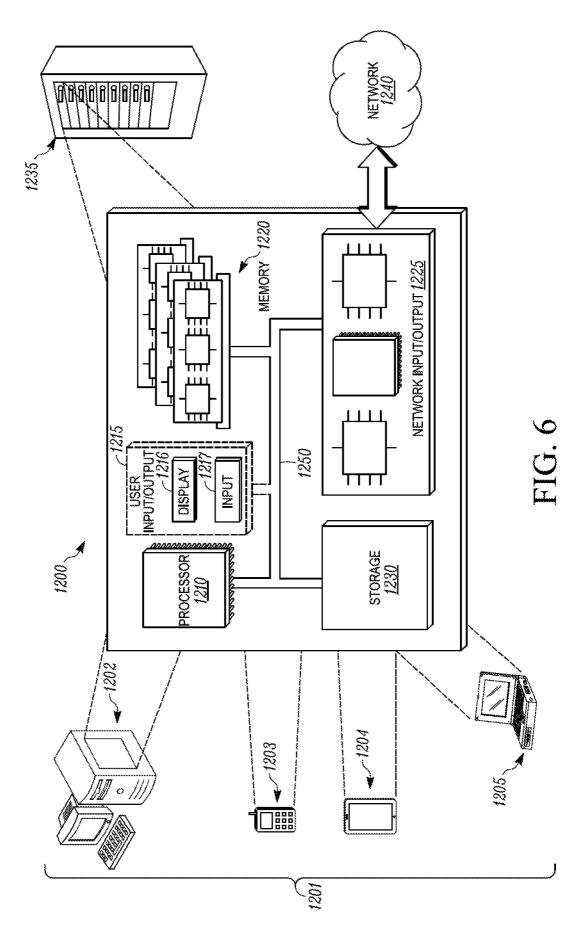


FIG. 5B



A. CLASSIFICATION OF SUBJECT MATTER H03M 7/46(2006.01)i, G06F 21/31(2013.01)i, G06F 21/62(2013.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols) H03M 7/46; H04L 9/08; H03M 7/30; H03M 1/34; H03M 5/14; G01S 5/02; G06F 21/3 1; G06F 21/62

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS(KIPO internal) & Keywords: admission key, traveral path, transform, compressed data segments, sort, multi-dimensional run-length encoding

C. DOCUMENTS CONSIDERED TO BE RELEVANT							
Category' *	Relevant to claim No.						
А	US 2015-0311916 Al (LAURI AARNE JOHANNES WIRO See paragraphs [0039H0068] , [0092H0171] ;	1-15					
А	US 2009-0060198 Al (MARK CAMERON LITTLE) 05 M See paragraphs [0023]- [0068] ; and f igures 1A	1-15					
А	EP 2381579Al(ITRON METERING SOLUTIONS UK LTSee paragraphs[0024] - [0039]; and f igures5-7	1-15					
А	US 2014-0104083 Al (WUHAN TEXTILE UNIVERSITY) See paragraphs [0089]- [0106] ', and f igures 8-11	1-15					
А	US 2008-0024350 Al (SUDARSHAN LAKSHMIPU SRINI) See paragraphs [0034]- [0044] ; and f igures 1,	1-15					
I Further documents are listed in the continuation of Box C. See patent family annex.							
"A" docum to be o "E" earlier filing o "L" docum cited to special "O" docum means "P" docum	 to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "L" document referring to an oral disclosure, use, exhibition or other means "L" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is taken alone "Y" document referring to an oral disclosure, use, exhibition or other means 						
Date of the	actual completion of the international search	Date of mailing of the international search rep					
	05 December 20 17 (05. 12.20 17) 12 December 2017 (12.12.2017)						
Name and	mailing address of the ISA/KR International Application Division Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea	Authorized officer AHN, Jeong Hwan	(III)				
Facsimile 1	Facsimile No. +82-42-481-8578 Telephone No. +82-42-481-8633						

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/048207

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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