Method of Binary Structures Compression on Basis of Cascade Encoding in Telecommunication Systems

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Annotation – **Grounded, that due to presentation of binary array as integral structure as a cascade structural number, additional reduction of structural surplus is provided. A cascade structural number is the number which satisfies limits on the number of units carouses and on the dynamic range of one-dimensional floating structural numbers (OSN) codes. The theorem is proved about forming of cod-number for a cascade structural number. It is shown, that amount of digits on presentation of binary column, which is examined as an element of cascade structural number less than, amount of digits on presentation of that column, but examined as a one-dimensional floating structural number.**

I. State of Problem and Analysis of Literature

The features of information treatment in the telecommunication systems consist of treatment uneven binary sequences are given. Sequences have an arbitrary structure and different statistical descriptions. For the telecommunication systems different intensity of traffic, origin of turns and duplication packages, are characteristic. It results in the additional increase of information volumes, processed and transferable in the telecommunication systems (TCS) [1]. Such circumstances are reason of leading time increase to information. From here is the scientifically-applied task which consists in diminishing of binary information volumes in TCS.

Direction of task decision consists in organization of binary information compact presentation [2 - 5]. One from the effective methods of compression is based on the one-dimensional structural encoding [6]. However for such encoding there is failing. Failing consists of amount M digits on a code view C_ν determined, as $M = [\ell og_2 V_{\nu,\eta}] + 1$ beaten. From other side for the value of code inequality can be executed

$$C_\nu <<< V_{\nu,\eta} . \quad (1)$$

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Then for the real length $\ell og_2 C_\nu$ codegrams a condition is executed

$$\ell og_2 C_\nu <<< [\ell og_2 V_{\nu,\eta}] + 1 . \quad (2)$$

Plenty of no significant digits, equal, appear in this case $[\ell og_2 V_{\nu,\eta}] + 1 - \ell og_2 C_\nu$ to the bats. Such amounts of digits are surplus and results in the decline of binary matrices ratio aspect.

It means that it is needed to provide the additional increase of compression information degree in the conditions of arbitrary binary structure. Therefore the purpose of researches consists of method compression development without loss of information on the basis of account two cascade structures of binary arrays.

II. Basic Material

We will consider the removal of failing, which was related to the choice of large length codegram on presentation of one-dimensional structural number cod-number. It is suggested to examine the aggregate of separate binary columns (OSN of numbers) taking into account additional limits on their dynamic ranges

$$C_\nu <<< \lambda_\nu . \quad (3)$$

In this case binary arrays are examined as integral structural objects.

Determination 1. By the cascade structural number $G^{(2)}$ binary arrays are named (sequence of columns, made from binary elements $g_{k\ell} \in [0;1]$), the columns of which are one-dimensional floating structural numbers which the number of units carouses is certain for

$$G^{(\ell)} = \{g_{k\ell}\}_{k=\overline{1,n}} \to \eta_\ell , \quad (4)$$

and values of codes-numbers C_ℓ limited from above by sizes $F(\eta,\lambda)_\ell$:

$$C_\ell < F(\eta,\lambda)_\ell = \min(V_{\ell,\nu,\eta}; \lambda_\ell) , \ \ell = \overline{1,n} . \quad (5)$$

Determination 2. By the great number $\Omega^{(2)}_{n,\eta,\lambda}$ possible cascade structural numbers (CSN) a great number, which consists of two regularities binary arrays which terms are executed for, is named:

1) number of units carouses for ℓ column of array equal η_ℓ, $\ell = \overline{1,n}$;

2) size of code C_ℓ, formed for ℓ OSN, limited from above by a size $\min(V_{\ell,\nu,\eta};\lambda_\ell)$, $\ell=\overline{1,n}$.

For determination of great number volume $\Omega^{(2)}_{n,\eta,\lambda}$ we will formulate and will prove a next theorem.

The theorem about the great number volume cascade structural numbers. Amount $V^{(2)}_{n,\eta,\lambda}$ cascade structural numbers which satisfy limitations (4) and (5), equal

$$V^{(2)}_{n,\eta,\lambda}=\prod_{\ell=1}^{n}F(\eta,\lambda)_\ell\,, \tag{6}$$

$$F(\eta,\lambda)_\ell=\min(V_{\ell,\nu,\eta};\lambda_\ell)\,,\ \ell=\overline{1,n} \tag{7}$$

$$V_{\ell,\nu,\eta}=(\nu+1)!/(2\eta_\ell)!\ (\nu+1-2\eta_\ell)!, \tag{8}$$

where η_ℓ – value of units carouses number for ℓ OSN of binary array; ν – length of OPSCH, in special case equal $\nu=n$.

Proof. As on the first cascade columns of CSN are OSN of number, that value of their code is even C_ℓ.

From other side of size C_ℓ are array cells C.

Then there are variants, when one of inequalities are executed

$$\max_{1\le\psi\le\Psi}\{C_{\ell\psi}\}+1<V_{\ell,\nu,\eta}$$

or

$$\max_{1\le\psi\le\Psi}\{C_{\ell\psi}\}+1\ge V_{\ell,\nu,\eta}\,.$$

Therefore size C_ℓ will limit by $F(\eta,\lambda)_\ell$:

$$C_\ell<F(\eta,\lambda)_\ell=\begin{cases}\lambda_\ell, & \to\lambda_\ell<V_{\ell,\nu,\eta};\\ V_{\ell,\nu,\eta}, & \to\lambda_\ell\ge V_{\ell,\nu,\eta}.\end{cases}$$

The amount of sequences, on the value of elements which limitations (4) is imposed and (5), is equal to the amount of transpositions with reiterations with limits on the dynamic range elements. The theorem is well-proven.

From the well-proven theorem about a volume $V^{(2)}_{n,\eta,\lambda}$ great numbers $\Omega^{(2)}_{n,\eta,\lambda}$ cascade structural numbers investigation flow out.

Investigation 1. For any known sizes η_ℓ, $\ell=\overline{1,n}$ has gotten for the sequence of one-dimensional floating structural numbers inequality, is executed between sizes $\sum_{\ell=1}^{n}\ell og_2V_{\nu,\eta_\ell}$ and $\ell og_2V^{(2)}_{n,\eta,\lambda}$:

$$\ell og_2V^{(2)}_{n,\eta,\lambda}\le\sum_{\ell=1}^{n}\ell og_2V_{\nu,\eta_\ell}\,. \tag{9}$$

where $\sum_{\ell=1}^{n}\ell og_2V_{\nu,\eta_\ell}$ – maximal total amount of digits on presentation sequences of OSN, which are examined as separate numbers;

$\ell og_2V^{(2)}_{n,\eta,\lambda}$ – maximal amount of digits on presentation of OSN sequence, is examined as a cascade structural number.

It means that as a result of cascade number forming on the basis of separate OSN reduction of digits amount is provided on their presentation in relation to an initial variant. This condition is executed taking into account situations, when $C_\nu <<< V_{\nu,\eta}$.

For forming of code a cascade structural number must develop the proper process of possible binary combinations numeration which belong to the great number $\Omega^{(2)}_{n,\eta,\lambda}$.

For this purpose we will formulate determination.

Determination 3. Cascade structural numeration of information is named the process of sequence number calculation, which occupies a cascade structural number in a possible great number $\Omega^{(2)}_{n,\eta,\lambda}$.

For the binary array $G=\{g_{k\ell}\}$, $k=\overline{1,n}$, $\ell=\overline{1,n}$, $g_{k\ell}\in\{0;1\}$, examined as CSN could be formed code $C^{(2)}$, which is calculated on the basis of expressions:

$$C^{(2)}=\sum_{\ell=1}^{n}\Big(\sum_{k=1}^{n}g_{k\ell}p_{k\ell}\Big)\prod_{\phi=\ell+1}^{n}F(\eta,\lambda)_\ell\,; \tag{10}$$

$$g_{0\ell}=0\,,\ \beta_{0\ell}=2\eta_\ell\,,\ \beta_{k\ell}=\beta_{k-1,\ell}-\left|g_{k-1,\ell}-g_{k\ell}\right|, \tag{11}$$

where $p_{k\ell}$ – value of gravimetric coefficient of element $g_{k\ell}$ one-dimensional floating structural number; n – an amount of binary elements is in OPSCH; $\beta_{k\ell}$ – recurrent parameter, equal to the amount of binary overfills (transitions between «0» and «1») for a sequence which consists of $(n-k+1)$ untilled elements.

For the construction of cascade code constructions $C^{(2)}_\psi$ required:

– to build arrays C, which consist of codes C_ν separate OSN values;

– to conduct the selection of dynamic ranges on the lines of array C.

The construction of the second cascade of code constructions is carried out in other words.

Determination 4. The cascade code constructions of OSN are named code constructions which are formed as a result of codes construction for an aggregate one the regularity of floating structural numbers.

Array C has the following kind:

$$C=\begin{vmatrix}C_{11} & \dots & C_{1\psi} & \dots & C_{1\Psi}\\ C_{\ell 1} & \dots & C_{\ell\psi} & \dots & C_{\ell\Psi}\\ C_{n1} & \dots & C_{n\psi} & \dots & C_{n\Psi}\end{vmatrix},$$

where $C_{\ell\psi}$ – code of one-dimensional floating structural number, formed on a base ℓ column ψ binary array; Ψ – amount of binary arrays for which cascade code constructions are formed.

The process of the cascade structural encoding includes the followings stages:

1. One-dimensional structural floating numbers are built by taking into account implementation of terms:

$$\sum_{\ell=1}^{2}([\ell og_2(V(\nu_\ell,\eta_\ell^{(\theta)}))]+1) \geq [\ell og_2 V_{\nu,\eta}]+1;$$

$$[\ell og_2 \eta_{max}+1]+1 \leq \sum_{\ell=1}^{2}([\ell og_2 \eta_{\ell,max}+1]+1),$$

where η_{max}, $\eta_{\ell,max}$ – maximal values of carouses number of units for OPSCH, which have length accordingly equal ν and ν_ℓ.

In this case $\nu=n$. It is suggested for utilized $n=8$.

2. The redistribution of official information is conducted depending on values $V_{\nu,\eta}$ volumes of possible great number of OPS numbers. Correlations are utilized for this purpose:

1) for ν even and η_{max} even:

$$\eta_{cp}=0;\ \text{if } \eta > \eta_{cp},\ \eta=2(\eta-\eta_{cp})-1;$$

$$\text{if } \eta < \eta_{cp},\ \eta = 2(\eta_{cp}-\eta);$$

2) for ν even and η_{max} odd:

$$\eta=\lceil(\nu+1)/4\rceil=0;\ \text{if } \eta > \lceil(\nu+1)/4\rceil,$$

$$\eta=2(\eta-\lceil(\nu+1)/4\rceil);$$

$$\text{if } \eta < \lceil(\nu+1)/4\rceil,\ \eta=2(\lceil(\nu+1)/4\rceil-\eta)-1$$

3) for ν odd and η_{max} even:

$$\eta_{cp}=0;\ \text{if } \eta > \eta_{cp},$$

$$\eta=2(\eta-\eta_{cp})-1;$$

$$\text{if } \eta < \eta_{cp},\ \eta=2(\eta_{cp}-\eta);$$

4) for ν odd and η_{max} odd:

$$\eta=\lceil(\nu+1)/4\rceil=0;\ \text{if } \eta > \lceil(\nu+1)/4\rceil,$$

$$\eta=2(\eta-\lceil(\nu+1)/4\rceil);$$

$$\text{if } \eta < \lceil(\nu+1)/4\rceil,\ \eta=2(\lceil(\nu+1)/4\rceil-\eta)-1;$$

3. For arrays the exposure of limits is carried out on dynamic ranges λ_ℓ, which are utilized for the calculation of gravimetric coefficients $F(\eta,\lambda)_\ell$:

$$\lambda_\ell = \max_{1\leq\psi\leq\Psi}\{C_{\ell\psi}\}+1, \tag{12}$$

where λ_ℓ – limit on the range of sizes $C_{\ell\psi}$ in ℓ to the line.

4. Forming of codes is conducted $C_\psi^{(2)}$ second cascade level, formed for ψ column of array C on the basis of parameters $\psi=\overline{1,\Psi}$:

$$C_\psi^{(2)} = \sum_{\ell=1}^{n}\left(\sum_{k=1}^{n} g_{k\ell}^{(\psi)} p_{k\ell}^{(\psi)}\right)\prod_{\phi=\ell+1}^{n} F(\eta,\lambda)_\phi; \tag{13}$$

$$g_{0\ell}=0,\ \beta_{0\ell}=2\eta_\ell,\ \beta_{k\ell}=\beta_{k-1,\ell}-\left|g_{k-1,\ell}-g_{k\ell}\right|, \tag{14}$$

where $g_{k\ell}^{(\psi)}$ – $(k;\ell)$ element ψ cascade structural number; $p_{k\ell}^{(\psi)}$ – gravimetric coefficient of element $g_{k\ell}^{(\psi)}$.

Next investigation follows from the features of cascade code structures forming.

Investigation 2. Value of code $C_\psi^{(2)}$ cascade structural number, where there will be a less size $V_{n,\eta,\lambda}^{(2)}$, which is equal to the total amount of CSN:

$$C_\psi^{(2)} < V_{n,\eta,\lambda}^{(2)} = \prod_{\ell=1}^{n} F(\eta,\lambda)_\ell. \tag{15}$$

On the basis of the well-proven investigation 2 flows out, that for preset the parameters n, λ_ℓ and $\{\eta_1,...,\eta_\ell,...,\eta_n\}$ by the high bound of digits amount, which are taken on a code view $C_\psi^{(2)}$ cascade structural number, there is a size $(\ell og_2 V_{n,\eta,\lambda}^{(2)}+1)$:

$$\ell og_2 C_\psi^{(2)} < 1+\ell og_2 V_{n,\eta,\lambda}^{(2)}. \tag{16}$$

Investigation 3. For the set values of sizes: lengths of OSN n, vector of limitations $F=\{F(\eta,\lambda)_\ell\}_{\ell=\overline{1,n}}$ and vector $\{\eta_1,...,\eta_\ell,...,\eta_n\}$ limits on the number of units carouses in the binary columns of cascade structural number, inequality is executed

$$\ell og_2 \overline{C}_\psi^{(2)} \leq \sum_{\ell=1}^{n}\ell og_2 C_{\ell\psi}/n, \tag{17}$$

where $\ell og_2 \overline{C}_\psi^{(2)}$ – middle on an amount n binary columns value of digits amount , which is expended on presentation of size $C_\psi^{(2)}$:

$$\ell og_2 \overline{C}_\psi^{(2)} = \ell og_2 C_\psi^{(2)}/n; \tag{18}$$

$\sum_{\ell=1}^{n}\ell og_2 C_{\ell\psi}/n$ – middle amount of digits, which is expended on presentation of one column, examined as a separate one-dimensional floating structural number.

Thus:

1. It has grounded that due to presentation of binary array as integral structure as a cascade structural number additional reduction of structural surplus is provided. The cascade structural number satisfies limitations on:

– number of units carouses;

– dynamic range of OPSCH codes.

2. The theorem is well - proved about forming code for a cascade structural number. On the basis of the well - proved theorem the high bound is determined for the amount of digits, code of CSN taken on presentation.

3. It is well-proven that amount of digits on binary column presentation, examined as an element of cascade structural number less, than amount of digits on presentation of that column, but examined as the one-dimensional floating structural number.

III. Conclusion

1. The methodological bases of the binary cascade structural encoding are created. A cascade structural number is a two dimension array for which:

- at the level of binary columns consideration is conducted as structural floating numbers;
- at the level of codes-numbers of separate columns additional limits come to light on a dynamic range.

In this case binary arrays are examined as integral structural objects.

2. Numeration of cascade structural numbers, which allows forming a codegram for an arbitrary binary array, is developed, taking into account structural limitations on two cascade levels. It is grounded on the basis of the built numeration, that:

- due to presentation of binary array as integral structure as a cascade structural number, satisfying limits on the number of units carouses and on the dynamic range of OSN codes, additional reduction of structural surplus is provided;
- there is a high bound for the amount of digits, code of CSN, which is taken on his presentation;
- amount of digits on presentation of binary column, examined as an element of cascade structural number less, than amount of that column digits on presentation, but which is examined as an one-dimensional floating structural number.

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