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KRASNOYARSK, RUSSIA

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«Application of modular turbo codes in authentication systems»

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Problem statement

The main goal is to use principles of turbo codes and modular codes in order to:

- increase the noise immunity of satellite communication systems;
- provide an authentication procedure for space crafts;
- use the same kind of code for both calculations during the execution of authentication protocol and forwarding information over communication channel.

Solution methods

- Turbo codes

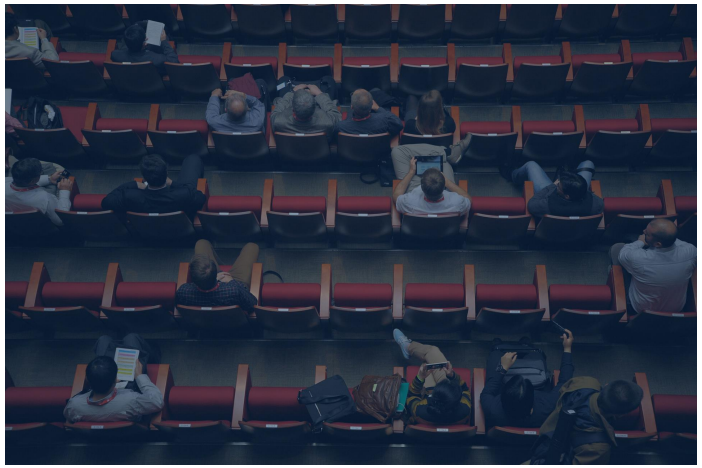
$$\begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} & h_{11} & h_{12} & \dots & h_{1k} \\ a_{21} & a_{22} & \dots & a_{2n} & h_{21} & h_{22} & \dots & h_{2k} \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} & h_{n1} & h_{n2} & \dots & h_{nk} \\ v_{11} & v_{21} & \dots & v_{n1} & c_{11} & c_{12} & \dots & c_{1k} \\ v_{12} & v_{22} & \dots & v_{n2} & c_{21} & c_{22} & \dots & c_{2k} \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ v_{1k} & v_{2k} & \dots & v_{nk} & c_{k1} & c_{k2} & \dots & c_{kk} \end{pmatrix}$$

- Modular codes

$$\gcd(m_i, m_j) = 1 \; \forall \; i \neq j$$

$$\widehat{M} = \prod_{i=1}^{n} m_i \, , M = \prod_{i=1}^{n+k} m_i = \widehat{M} \prod_{i=1}^{k} m_{n+i} \, ;$$

$$Y = (y_1, y_2, \dots, y_n, y_{n+1}, y_{n+2}, \dots, y_{n+k}), y_i = Y \bmod m_i.$$



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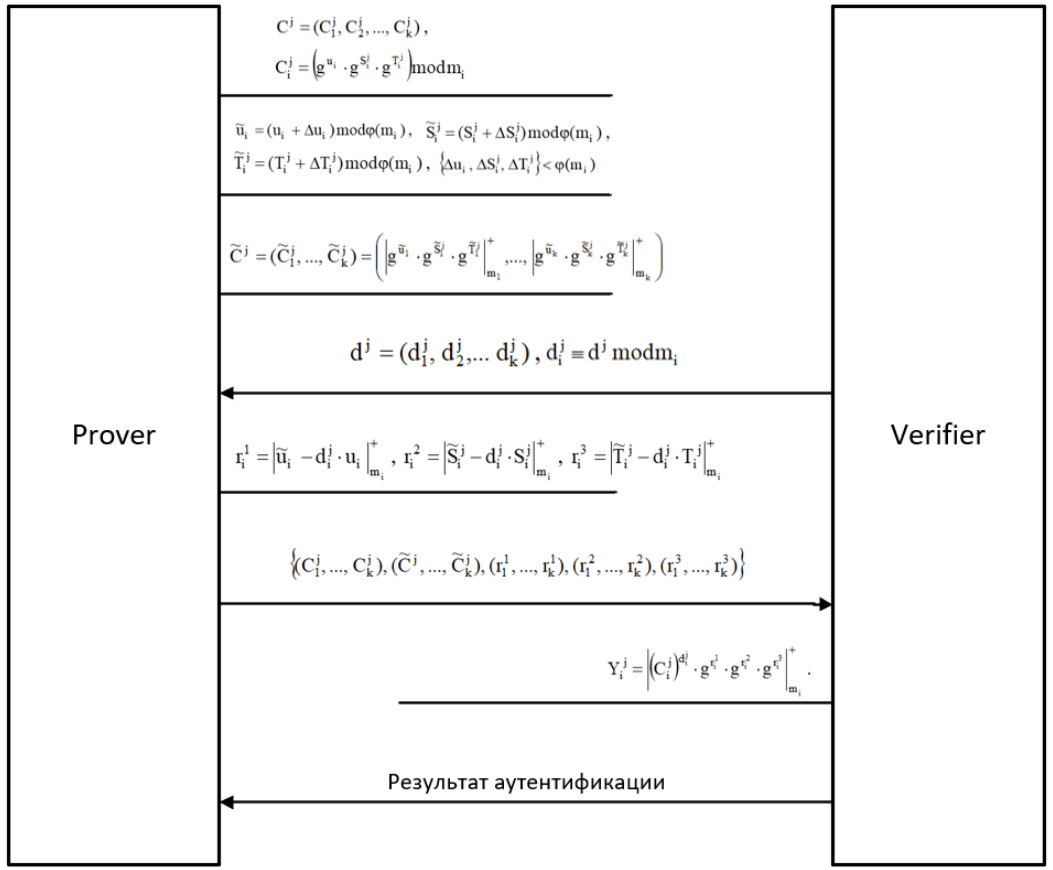
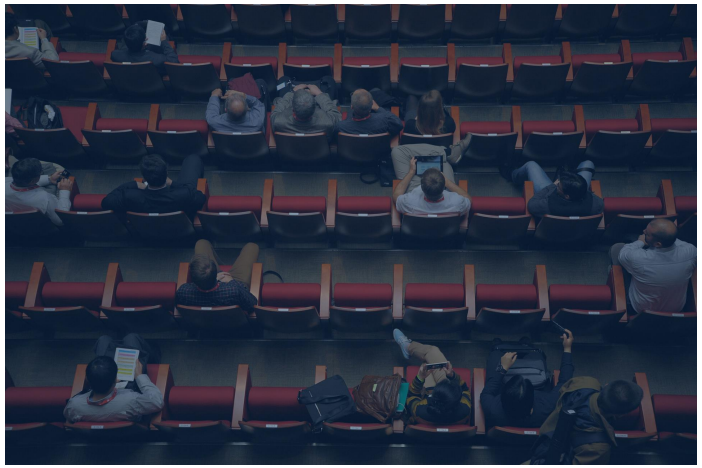
Solution methods

- Authentication protocol with usage of modular codes





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Solution methods

- Structure of the developed modular turbo code

$$\begin{matrix}(C_1^j, C_2^j, C_3^j, C_4^j, C_5^j),\\ (\widetilde{C}_1^j, \widetilde{C}_2^j, \widetilde{C}_3^j, \widetilde{C}_4^j, \widetilde{C}_5^j),\\ (r_1^1, r_2^1, r_3^1, r_4^1, r_5^1),\\ (r_1^2, r_2^2, r_3^2, r_4^2, r_5^2),\\ (r_1^3, r_2^3, r_3^3, r_4^3, r_5^3).\end{matrix} \Rightarrow A_{RNS} = \begin{cases}(\alpha_{11}, \alpha_{12}, \alpha_{13}, \alpha_{14}, \alpha_{15})\\ (\alpha_{21}, \alpha_{22}, \alpha_{23}, \alpha_{24}, \alpha_{25})\\ (\alpha_{31}, \alpha_{32}, \alpha_{33}, \alpha_{34}, \alpha_{35})\\ (\alpha_{41}, \alpha_{42}, \alpha_{43}, \alpha_{44}, \alpha_{45})\\ (\alpha_{51}, \alpha_{52}, \alpha_{53}, \alpha_{54}, \alpha_{55})\end{cases}$$

- Calculation of residues

$$\alpha_{v6}^1 = \left(\sum_{i=1}^{5} \alpha_{vi} B_i \bmod \hat{M}\right) \bmod m_6, \alpha_{v7}^1 = \left(\sum_{i=1}^{5} \alpha_{vi} B_i \bmod \hat{M}\right) \bmod m_7$$

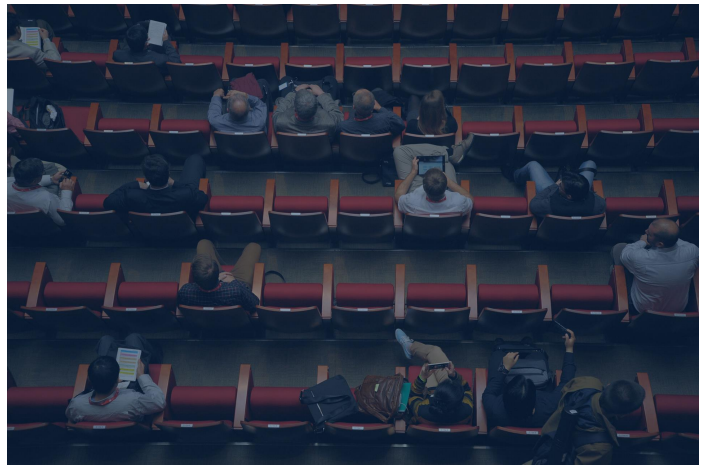
$$\alpha_{1j}^2 = \left|\left(\alpha_{11}B_1 + \alpha_{22}B_2 + \alpha_{33}B_3 + \alpha_{54}B_4 + \alpha_{55}B_5\right) \bmod \hat{M}\right|_{m_j}^+,$$

$$\alpha_{2j}^2 = \left|\left(\alpha_{21}B_1 + \alpha_{32}B_2 + \alpha_{43}B_3 + \alpha_{44}B_4 + \alpha_{25}B_5\right) \bmod \hat{M}\right|_{m_j}^+,$$

$$\alpha_{3j}^2 = \left|\left(\alpha_{31}B_1 + \alpha_{12}B_2 + \alpha_{53}B_3 + \alpha_{24}B_4 + \alpha_{15}B_5\right) \bmod \hat{M}\right|_{m_j}^+,$$

$$\alpha_{4j}^2 = \left|\left(\alpha_{41}B_1 + \alpha_{52}B_2 + \alpha_{13}B_3 + \alpha_{14}B_4 + \alpha_{35}B_5\right) \bmod \hat{M}\right|_{m_j}^+,$$

$$\alpha_{5j}^2 = \left|\left(\alpha_{51}B_1 + \alpha_{42}B_2 + \alpha_{23}B_3 + \alpha_{34}B_4 + \alpha_{55}B_5\right) \bmod \hat{M}\right|_{m_j}^+.$$



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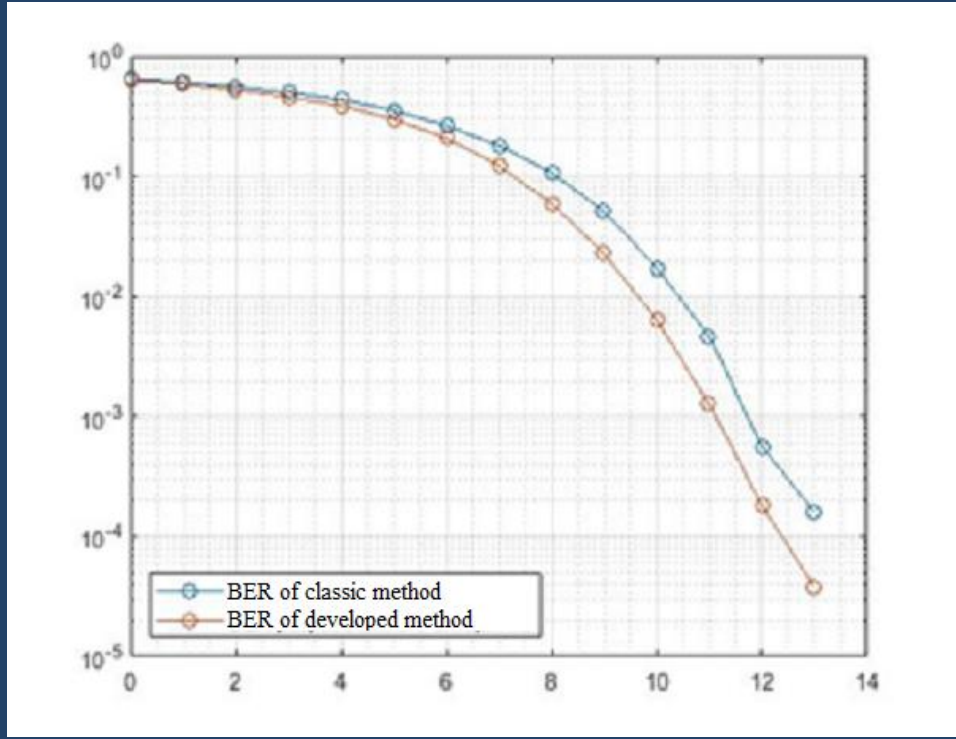
Conclusions



Bit error rates comparison

- Program simulation was created to compare the noise immunity of system for two cases: using not modified authentication protocol and using developed modular turbo code.
- When a signal-to-noise ratio is 13 dB, the probability of a system error using the developed method is $3 \cdot 10^{-5}$ while for the classic RNS it is $8.6 \cdot 10^{-5}$. It means an increase of noise immunity of the system in 2.86 times.

Contacts

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