PATENT COOPERATION TREATY

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PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2020/020427	28.02.2020	30.04.2019

International Patent Classification (IPC) or both national classification and IPC
INV. H04L1/00

Applicant
CODE ON NETWORK CODING, LLC

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:	Date of completion of this opinion	Authorized Officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Fax: +49 89 2399 - 4465	see form PCT/ISA/210	Martínez Martínez, V Telephone No. +49 89 2399-0

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2020/020427

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	
	No:	Claims	1-22
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-22
Industrial applicability (IA)	Yes:	Claims	1-22
	No:	Claims	

2. Citations and explanations

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following documents:

D1 WO 2014/074757 A2 (FACTOR COMM CORP Q [US]; ZHOVNIRNOVSKY IGOR; ROY SUBHASH C) 15 May 2014 (2014-05-15)

D2 US 2014/016469 A1 (HO TRACEY C [US] ET AL) 16 January 2014 (2014-01-16)

2 Article 33 PCT. Novelty and Inventive Step.

2.1 Independent claims.

The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of the independent claims is not new in the sense of Article 33(2) PCT.

2.1.1 Scope of protection.

The independent claims have been formulated in a broad manner and are not sufficiently differentiated from the prior art . With their current wording, the independent claims 1, 11 and 15 merely cover a method and apparatus wherein coding coefficients of a linear network code are either:

-parameters stored in local memory, or

-derived by a predetermined function from such parameters.

In the prior art, deterministic linear network coding (DLNC) is a well known alternative to the random generation of coding coefficients (RLNC). The idea behind DLNC is, precisely, the obtention of the coding coefficients in a predetermined, predictable way, usually from pre-stored sets of coefficients or functions.

2.1.2 Document D1.

Document D1 is cited in the Background section of the present Application. Given the broad scope of protection of the independent claims, document D1 is considered as a novelty destroying document. Using the wording of the independent claim 1, document D1 discloses:

A network node comprising:
a receiver for receiving input packets;

(D1, figure 2: continuous packet stream input to selector)

local node memory where one or more parameters for coding are stored;

(the existence of local memory can be implicitly assumed within the devices disclosed by document D1, particularly in view of the deterministic linear network coding detailed on pages 13, line 22 to page 16, line 17 and which is discussed in the following)
an encoder for creating coded packets from the input packets using linear network coding, wherein each coefficient of the linear network coding is a parameter of the one or more parameters, or a pre-determined function of the one or more parameters;

(D1, figure 2, encoder; page 14, quoted with added emphasis:

> "The method in a first preferred embodiment utilizes **a code book known to all communication network participants including intermediate nodes**. Information about either generating function or **"code book" is provided only once when a new user joins the network**. Hence, **coefficients are predictable** and the knowledge of the code book at both ends of the transmission eliminates the overhead for coefficient transmission or re-generation. A second preferred method uses a **pre-defined polynomial equation, e.g. Factorial, Fibonacci sequence, such that the coefficients need not be transferred** from and to each node involved in the transfer of information. With either preferred coefficient generation method, at each transmission opportunity, **a linear combination of packets is sent with a pre-determined set of coefficients**."

More details are provided on page 49, starting in line 14:

> "We have discovered that we can create linearly independent equations by using **pre-calculated coefficients and then distribute the coefficients in a codebook and send the code book to each node involved in the transfer of information**. An **alternative method to create these equations involves sending a pre-defined polynomial**

> **equation** (e.g. Factorial) such that the coefficients need not be transferred from or to each node involved in the transfer of information, just the first and last node.The code book or polynomial that is known a priori enables the destination point to understand what the appropriate coefficients are to enable decoding of the linear equations that are transferred and enable the recreations of the original variables (i.e. packets). A system designer may choose to implement DLNC in connection with a pre-determined code book or code books. One benefit of this system is that **the code book can be re- provisioned, similar to cipher mechanisms, such that in midst of a transfer, the code book can be changed.**"

Accordingly, document D1 discloses that the coefficients for linear combining are either pre-computed, as a part of an a priori known code book, or computed according to predetermined equations known to each node. As stated in the foregoing, it is implicit that the node stores either the code-book or the mentioned equations in local memory.

It is also noted that, in the passages cited above, document D1 discloses that the code book can be provided when the user joins the network, but it can also be changed afterwards.)

`and a transmitter to transmit the coded packets`

(D1, figure 2, transmitter)

Therefore, the subject matter of the independent claim 1 is known from document D1. The same applies to the corresponding method and network of the independent claims 11 and 15.

2.1.3 Document D2.

Document D2 has also been cited within the Background section of the present Application.

Document D2 discloses the deterministic determination of the coding coefficients according to locally stored information:

> " In particular, **the coefficients of the linear combination** (the coding coefficients) are **deterministically chosen based on local information available locally at the coding node**.By way of example, the coefficients are chosen from a code alphabet (the set of possible values of the coding coefficients) such as a finite or infinite ring or field."

(paragraph 0012, emphasis added)

This locally available information can be, as disclosed in paragraphs 0030 to 0032, node identifiers, IP addresses, device serial numbers, etc. The coefficients are computed according to deterministic functions performed on the local information, optionally also taking into account the time index. Such deterministic functions are known to the transmitter and receiver nodes.

Consequently, document D2 is also novelty destroying to the subject matter of the independent claims 1, 11 and 15 (Article 33(2) PCT).

2.2 Dependent claims.

-claim 2: as shown in figure 2 of D1, data packets are stored before coding.

-claims 3, 16: known from both documents D1 and D2, see passages cited in the foregoing. Please note that the Fibonacci sequences of D1 are, by definition, recursive. This means that current coefficients are to be computed as a function of preceding coefficients, in the sense of the present Application (e.g. figure 6 of the Application, block 650).

-claims 4, 5, 7: as discussed in section 2.1.2, the code book of D1 is transmitted to the device when joining the network and can be fixed or changed afterwards.

-claims 5, 6: as discussed in section 2.1.3, the node identifiers od D2 can be derived from the device serial number.

-claim 8: the code book of D1 and the mod operation of D2 indicate loops within a finite number of possible coefficients.

-claims 9, 10, 17: known from D1 (references on page 14) to Fibonacci sequences, which can be assumed to be re-initialized at some point, in order to have a finite number of possible coefficients.

-claims 12, 13: the selector of document D1 separates guaranteed data from non-guaranteed data (page 7, lines 10 and 11).

-claim 14: In D1, the number M of combined packets can be adjusted according to the packet loss (pages 21-23).

-claims 18-21: D2, equations 2,3, 5, 6.

-claim 22: both in D1 and D2, the coefficients are computed in a deterministic manner precisely to avoid complexity and network overhead.