JOURNAL OF FORMALIZED MATHEMATICS
Volume 9, Released 1997, Published 2003
Inst. of Computer Science, Univ. of Białystok

On the Categories Without Uniqueness of cod and dom . Some Properties of the Morphisms and the Functors

Artur Korniłowicz
University of Białystok

MML Identifier: ALTCAT_4.

WWW: http://mizar.org/JFM/Vol9/altcat_4.html

The articles [8], [4], [14], [2], [3], [1], [7], [9], [10], [5], [11], [12], [6], and [13] provide the notation and terminology for this paper.

1. Preliminaries

In this paper C denotes a category and o_1, o_2, o_3 denote objects of C.

Let C be a non empty category structure with units and let o be an object of C. Note that $\langle o,o \rangle$ is non empty.

Next we state four propositions:

(1) Let v be a morphism from o_1 to o_2, u be a morphism from o_1 to o_3, and f be a morphism from o_2 to o_3. If $u = f \cdot v$ and $f^{-1} \cdot f = \mathrm{id}_{(o_2)}$ and $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_3 \rangle \neq \emptyset$ and $\langle o_3, o_2 \rangle \neq \emptyset$, then $v = f^{-1} \cdot u$.

(2) Let v be a morphism from o_2 to o_3, u be a morphism from o_1 to o_3, and f be a morphism from o_1 to o_2. If $u = v \cdot f$ and $f \cdot f^{-1} = \mathrm{id}_{(o_2)}$ and $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and $\langle o_2, o_3 \rangle \neq \emptyset$, then $v = u \cdot f^{-1}$.

(3) For every morphism m from o_1 to o_2 such that $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and m is iso holds m^{-1} is iso.

(4) For every non empty category structure C with units and for every object o of C holds id_o is epi and mono.

Let C be a non empty category structure with units and let o be an object of C. One can check that id_o is epi, mono, retraction, and coretraction.

Let C be a category and let o be an object of C. Observe that id_o is iso.

Next we state two propositions:

(5) Let f be a morphism from o_1 to o_2 and g, h be morphisms from o_2 to o_1. If $h \cdot f = \mathrm{id}_{(o_1)}$ and $f \cdot g = \mathrm{id}_{(o_2)}$ and $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$, then $g = h$.

(6) Suppose that for all objects o_1, o_2 of C holds every morphism from o_1 to o_2 is coretraction. Let a, b be objects of C and g be a morphism from a to b. If $\langle a, b \rangle \neq \emptyset$ and $\langle b, a \rangle \neq \emptyset$, then g is iso.

2. Some properties of the initial and terminal objects

One can prove the following propositions:

(7) For all morphisms m, m' from o_1 to o_2 such that m is zero and m' is zero and there exists an object of C which is zero holds $m = m'$.

(8) Let C be a non empty category structure, O, A be objects of C, and M be a morphism from O to A. If O is terminal, then M is mono.

(9) Let C be a non empty category structure, O, A be objects of C, and M be a morphism from A to O. If O is initial, then M is epi.

(10) If o_2 is terminal and o_1, o_2 are iso, then o_1 is terminal.

(11) If o_1 is initial and o_1, o_2 are iso, then o_2 is initial.

(12) If o_1 is initial and o_2 is terminal and $\langle o_2, o_1 \rangle \neq \emptyset$, then o_2 is initial and o_1 is terminal.

3. The properties of the functors

We now state a number of propositions:

(13) Let A, B be transitive non empty category structures with units, F be a contravariant functor from A to B, and a be an object of A. Then $F(\mathrm{id}_a) = \mathrm{id}_{F(a)}$.

(14) Let C_1, C_2 be non empty category structures and F be a precontravariant functor structure from C_1 to C_2. Then F is full if and only if for all objects o_1, o_2 of C_1 holds $\text{Morph-Map}_F(o_2, o_1)$ is onto.

(15) Let C_1, C_2 be non empty category structures and F be a precontravariant functor structure from C_1 to C_2. Then F is faithful if and only if for all objects o_1, o_2 of C_1 holds $\text{Morph-Map}_F(o_2, o_1)$ is one-to-one.

(16) Let C_1, C_2 be non empty category structures, F be a precovariant functor structure from C_1 to C_2, o_1, o_2 be objects of C_1, and F_1 be a morphism from $F(o_1)$ to $F(o_2)$. Suppose $\langle o_1, o_2 \rangle \neq \emptyset$ and F is full and feasible. Then there exists a morphism m from o_1 to o_2 such that $F_1 = F(m)$.

(17) Let C_1, C_2 be non empty category structures, F be a precontravariant functor structure from C_1 to C_2, o_1, o_2 be objects of C_1, and F_1 be a morphism from $F(o_2)$ to $F(o_1)$. Suppose $\langle o_1, o_2 \rangle \neq \emptyset$ and F is full and feasible. Then there exists a morphism m from o_1 to o_2 such that $F_1 = F(m)$.

(18) Let A, B be transitive non empty category structures with units, F be a covariant functor from A to B, o_1, o_2 be objects of A, and a be a morphism from o_1 to o_2. If $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and a is retraction, then $F(a)$ is retraction.

(19) Let A, B be transitive non empty category structures with units, F be a covariant functor from A to B, o_1, o_2 be objects of A, and a be a morphism from o_1 to o_2. If $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and a is coretraction, then $F(a)$ is coretraction.

(20) Let A, B be categories, F be a covariant functor from A to B, o_1, o_2 be objects of A, and a be a morphism from o_1 to o_2. If $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and a is iso, then $F(a)$ is iso.

(21) Let A, B be categories, F be a covariant functor from A to B, and o_1, o_2 be objects of A. If o_1, o_2 are iso, then $F(o_1)$, $F(o_2)$ are iso.

(22) Let A, B be transitive non empty category structures with units, F be a contravariant functor from A to B, o_1, o_2 be objects of A, and a be a morphism from o_1 to o_2. If $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and a is retraction, then $F(a)$ is coretraction.

(23) Let A, B be transitive non empty category structures with units, F be a contravariant functor from A to B, o_1, o_2 be objects of A, and a be a morphism from o_1 to o_2. If $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and a is coretraction, then $F(a)$ is retraction.

(24) Let A, B be categories, F be a contravariant functor from A to B, o_1, o_2 be objects of A, and a be a morphism from o_1 to o_2. If $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and a is iso, then $F(a)$ is iso.

(25) Let A, B be categories, F be a contravariant functor from A to B, and o_1, o_2 be objects of A. If o_1, o_2 are iso, then $F(o_2)$, $F(o_1)$ are iso.

(26) Let A, B be transitive non empty category structures with units, F be a covariant functor from A to B, o_1, o_2 be objects of A, and a be a morphism from o_1 to o_2. Suppose F is full and faithful and $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and $F(a)$ is retraction. Then a is retraction.

(27) Let A, B be transitive non empty category structures with units, F be a covariant functor from A to B, o_1, o_2 be objects of A, and a be a morphism from o_1 to o_2. Suppose F is full and faithful and $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and $F(a)$ is coretraction. Then a is coretraction.

(28) Let A, B be categories, F be a covariant functor from A to B, o_1, o_2 be objects of A, and a be a morphism from o_1 to o_2. Suppose F is full and faithful and $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and $F(a)$ is iso. Then a is iso.

(29) Let A, B be categories, F be a covariant functor from A to B, and o_1, o_2 be objects of A. Suppose F is full and faithful and $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and $F(o_1)$, $F(o_2)$ are iso. Then o_1, o_2 are iso.

(30) Let A, B be transitive non empty category structures with units, F be a contravariant functor from A to B, o_1, o_2 be objects of A, and a be a morphism from o_1 to o_2. Suppose F is full and faithful and $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and $F(a)$ is retraction. Then a is coretraction.

(31) Let A, B be transitive non empty category structures with units, F be a contravariant functor from A to B, o_1, o_2 be objects of A, and a be a morphism from o_1 to o_2. Suppose F is full and faithful and $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and $F(a)$ is coretraction. Then a is retraction.

(32) Let A, B be categories, F be a contravariant functor from A to B, o_1, o_2 be objects of A, and a be a morphism from o_1 to o_2. Suppose F is full and faithful and $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and $F(a)$ is iso. Then a is iso.

(33) Let A, B be categories, F be a contravariant functor from A to B, and o_1, o_2 be objects of A. Suppose F is full and faithful and $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and $F(o_2)$, $F(o_1)$ are iso. Then o_1, o_2 are iso.

4. The subcategories of the morphisms

We now state two propositions:

(34) Let C be a category structure and D be a substructure of C. Suppose the carrier of $C =$ the carrier of D and the arrows of $C =$ the arrows of D. Then D is full.

(35) Let C be a non empty category structure with units and D be a substructure of C. Suppose the carrier of $C =$ the carrier of D and the arrows of $C =$ the arrows of D. Then D is full and id-inheriting.

Let C be a category. One can verify that there exists a subcategory of C which is full, non empty, and strict.

The following propositions are true:

(36) For every non empty subcategory B of C holds every non empty subcategory of B is a non empty subcategory of C.

(37) Let C be a non empty transitive category structure, D be a non empty transitive substructure of C, o_1, o_2 be objects of C, p_1, p_2 be objects of D, m be a morphism from o_1 to o_2, and n be a morphism from p_1 to p_2 such that $p_1 = o_1$ and $p_2 = o_2$ and $m = n$ and $\langle p_1, p_2 \rangle \neq \emptyset$. Then

(i) if m is mono, then n is mono, and

(ii) if m is epi, then n is epi.

(38) Let D be a non empty subcategory of C, o_1, o_2 be objects of C, p_1, p_2 be objects of D, m be a morphism from o_1 to o_2, m_1 be a morphism from o_2 to o_1, n be a morphism from p_1 to p_2, and n_1 be a morphism from p_2 to p_1 such that $p_1 = o_1$ and $p_2 = o_2$ and $m = n$ and $m_1 = n_1$ and $\langle p_1, p_2 \rangle \neq \emptyset$ and $\langle p_2, p_1 \rangle \neq \emptyset$. Then

(i) m is left inverse of m_1 iff n is left inverse of n_1, and

(ii) m is right inverse of m_1 iff n is right inverse of n_1.

(39) Let D be a full non empty subcategory of C, o_1, o_2 be objects of C, p_1, p_2 be objects of D, m be a morphism from o_1 to o_2, and n be a morphism from p_1 to p_2 such that $p_1 = o_1$ and $p_2 = o_2$ and $m = n$ and $\langle p_1, p_2 \rangle \neq \emptyset$ and $\langle p_2, p_1 \rangle \neq \emptyset$. Then

(i) if m is retraction, then n is retraction,

(ii) if m is coretraction, then n is coretraction, and

(iii) if m is iso, then n is iso.

(40) Let D be a non empty subcategory of C, o_1, o_2 be objects of C, p_1, p_2 be objects of D, m be a morphism from o_1 to o_2, and n be a morphism from p_1 to p_2 such that $p_1 = o_1$ and $p_2 = o_2$ and $m = n$ and $\langle p_1, p_2 \rangle \neq \emptyset$ and $\langle p_2, p_1 \rangle \neq \emptyset$. Then

(i) if n is retraction, then m is retraction,

(ii) if n is coretraction, then m is coretraction, and

(iii) if n is iso, then m is iso.

Let C be a category. The functor AllMono$C$ yielding a strict non empty transitive substructure of C is defined by the conditions (Def. 1).

(Def. 1)(i) The carrier of AllMono$C$ = the carrier of C,

(ii) the arrows of AllMono$C$ $\dot{\subseteq}$ the arrows of C, and

(iii) for all objects o_1, o_2 of C and for every morphism m from o_1 to o_2 holds $m \in$ (the arrows of AllMono$C$)(o_1, o_2) iff $\langle o_1, o_2 \rangle \neq \emptyset$ and m is mono.

Let C be a category. One can check that AllMono$C$ is id-inheriting.

Let C be a category. The functor AllEpi$C$ yields a strict non empty transitive substructure of C and is defined by the conditions (Def. 2).

(Def. 2)(i) The carrier of AllEpi$C$ = the carrier of C,

(ii) the arrows of AllEpi$C$ $\dot{\subseteq}$ the arrows of C, and

(iii) for all objects o_1, o_2 of C and for every morphism m from o_1 to o_2 holds $m \in$ (the arrows of AllEpi$C$)(o_1, o_2) iff $\langle o_1, o_2 \rangle \neq \emptyset$ and m is epi.

Let C be a category. Observe that AllEpi$C$ is id-inheriting.

Let C be a category. The functor AllRetr$C$ yields a strict non empty transitive substructure of C and is defined by the conditions (Def. 3).

(Def. 3)(i) The carrier of AllRetr$C$ = the carrier of C,

(ii) the arrows of AllRetr$C$ $\dot{\subseteq}$ the arrows of C, and

(iii) for all objects o_1, o_2 of C and for every morphism m from o_1 to o_2 holds $m \in$ (the arrows of AllRetr$C$)(o_1, o_2) iff $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and m is retraction.

Let C be a category. Note that AllRetr$C$ is id-inheriting.

Let C be a category. The functor AllCoretr$C$ yields a strict non empty transitive substructure of C and is defined by the conditions (Def. 4).

(Def. 4)(i) The carrier of AllCoretr$C$ = the carrier of C,

(ii) the arrows of AllCoretr$C \dot{\subseteq}$ the arrows of C, and

(iii) for all objects o_1, o_2 of C and for every morphism m from o_1 to o_2 holds $m \in$ (the arrows of AllCoretr$C)(o_1, o_2)$ iff $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and m is coretraction.

Let C be a category. One can verify that AllCoretr$C$ is id-inheriting.

Let C be a category. The functor AllIso$C$ yields a strict non empty transitive substructure of C and is defined by the conditions (Def. 5).

(Def. 5)(i) The carrier of AllIso$C$ = the carrier of C,

(ii) the arrows of AllIso$C \dot{\subseteq}$ the arrows of C, and

(iii) for all objects o_1, o_2 of C and for every morphism m from o_1 to o_2 holds $m \in$ (the arrows of AllIso$C)(o_1, o_2)$ iff $\langle o_1, o_2 \rangle \neq \emptyset$ and $\langle o_2, o_1 \rangle \neq \emptyset$ and m is iso.

Let C be a category. One can verify that AllIso$C$ is id-inheriting.

We now state a number of propositions:

(41) AllIso$C$ is a non empty subcategory of AllRetr$C$.

(42) AllIso$C$ is a non empty subcategory of AllCoretr$C$.

(43) AllCoretr$C$ is a non empty subcategory of AllMono$C$.

(44) AllRetr$C$ is a non empty subcategory of AllEpi$C$.

(45) If for all objects o_1, o_2 of C holds every morphism from o_1 to o_2 is mono, then the category structure of C = AllMono$C$.

(46) If for all objects o_1, o_2 of C holds every morphism from o_1 to o_2 is epi, then the category structure of C = AllEpi$C$.

(47) Suppose that for all objects o_1, o_2 of C and for every morphism m from o_1 to o_2 holds m is retraction and $\langle o_2, o_1 \rangle \neq \emptyset$. Then the category structure of C = AllRetr$C$.

(48) Suppose that for all objects o_1, o_2 of C and for every morphism m from o_1 to o_2 holds m is coretraction and $\langle o_2, o_1 \rangle \neq \emptyset$. Then the category structure of C = AllCoretr$C$.

(49) Suppose that for all objects o_1, o_2 of C and for every morphism m from o_1 to o_2 holds m is iso and $\langle o_2, o_1 \rangle \neq \emptyset$. Then the category structure of C = AllIso$C$.

(50) For all objects o_1, o_2 of AllMono$C$ and for every morphism m from o_1 to o_2 such that $\langle o_1, o_2 \rangle \neq \emptyset$ holds m is mono.

(51) For all objects o_1, o_2 of AllEpi$C$ and for every morphism m from o_1 to o_2 such that $\langle o_1, o_2 \rangle \neq \emptyset$ holds m is epi.

(52) For all objects o_1, o_2 of AllIso$C$ and for every morphism m from o_1 to o_2 such that $\langle o_1, o_2 \rangle \neq \emptyset$ holds m is iso and $m^{-1} \in \langle o_2, o_1 \rangle$.

(53) AllMono AllMono$C$ = AllMono$C$.

(54) AllEpi AllEpi$C$ = AllEpi$C$.

(55) AllIso AllIso$C$ = AllIso$C$.

(56) AllIso AllMono$C$ = AllIso$C$.

(57) AllIso AllEpi$C$ = AllIso$C$.

(58) AllIso AllRetr$C$ = AllIso$C$.

(59) AllIso AllCoretr$C$ = AllIso$C$.

REFERENCES

[1] Czesław Byliński. Binary operations. *Journal of Formalized Mathematics*, 1, 1989. http://mizar.org/JFM/Vol1/binop_1.html.

[2] Czesław Byliński. Functions and their basic properties. *Journal of Formalized Mathematics*, 1, 1989. http://mizar.org/JFM/Vol1/funct_1.html.

[3] Czesław Byliński. Functions from a set to a set. *Journal of Formalized Mathematics*, 1, 1989. http://mizar.org/JFM/Vol1/funct_2.html.

[4] Czesław Byliński. Some basic properties of sets. *Journal of Formalized Mathematics*, 1, 1989. http://mizar.org/JFM/Vol1/zfmisc_1.html.

[5] Małgorzata Korolkiewicz. Homomorphisms of many sorted algebras. *Journal of Formalized Mathematics*, 6, 1994. http://mizar.org/JFM/Vol6/msualg_3.html.

[6] Beata Madras-Kobus. Basic properties of objects and morphisms. *Journal of Formalized Mathematics*, 9, 1997. http://mizar.org/JFM/Vol9/altcat_3.html.

[7] Michał Muzalewski and Wojciech Skaba. Three-argument operations and four-argument operations. *Journal of Formalized Mathematics*, 2, 1990. http://mizar.org/JFM/Vol2/multop_1.html.

[8] Andrzej Trybulec. Tarski Grothendieck set theory. *Journal of Formalized Mathematics*, Axiomatics, 1989. http://mizar.org/JFM/Axiomatics/tarski.html.

[9] Andrzej Trybulec. Many-sorted sets. *Journal of Formalized Mathematics*, 5, 1993. http://mizar.org/JFM/Vol5/pboole.html.

[10] Andrzej Trybulec. Many sorted algebras. *Journal of Formalized Mathematics*, 6, 1994. http://mizar.org/JFM/Vol6/msualg_1.html.

[11] Andrzej Trybulec. Categories without uniqueness of cod and dom. *Journal of Formalized Mathematics*, 7, 1995. http://mizar.org/JFM/Vol7/altcat_1.html.

[12] Andrzej Trybulec. Examples of category structures. *Journal of Formalized Mathematics*, 8, 1996. http://mizar.org/JFM/Vol8/altcat_2.html.

[13] Andrzej Trybulec. Functors for alternative categories. *Journal of Formalized Mathematics*, 8, 1996. http://mizar.org/JFM/Vol8/functor0.html.

[14] Edmund Woronowicz. Relations and their basic properties. *Journal of Formalized Mathematics*, 1, 1989. http://mizar.org/JFM/Vol1/relat_1.html.

Received October 3, 1997

Published January 2, 2004